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EDITED BY HENRY LAWSON, M.D.

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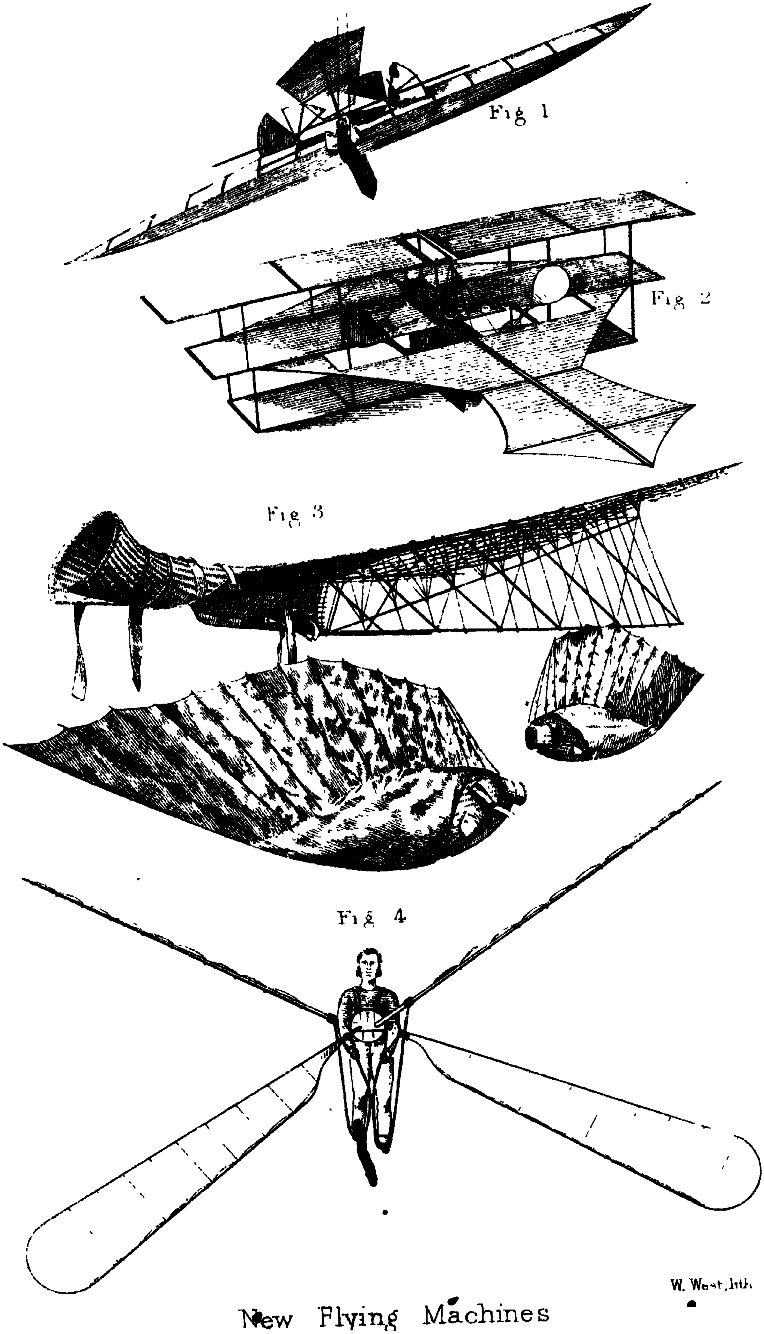
Plate XXXVI



W. West, lith.

New Flying Machines

POPULAR SCIENCE REVIEW.

FLYING MACHINES.

BY FRED. W. BREAREY.

HONORARY SECRETARY TO THE AËRONAUTICAL SOCIETY OF GREAT BRITAIN.

IN its normal state, the air is inapplicable as a power, but it is capable of becoming an overwhelming power, either by natural or artificial causes, as in the whirlwind and tornado or by rushing forcibly through it, as would be exemplified were the sails of a windmill rotated rapidly against it.

Thus the bird may create for itself in a calm, by the agitation of its wing-surface, the power which supports and prolongs its flight in a horizontal or ascending line; but is also capable, in the calm of a sultry summer's day, by the mere momentum of its own weight, of gliding for an immense distance upon an unyielding plane, thus converting the inert air into a fulcrum or support.

In such a case, two only of the three requisites for successful flight are brought into action, viz. surface and weight, the third, force, being held in reserve for extraordinary occasions.

This gliding motion, the writer has observed in a parachute which detached upon one occasion at no great height above his head on a calm evening sailed away down a gradually inclined plane.

It is upon bodies like these possessing extended surface, and brought under the influence of gravitation, that experiments are required.

There can be no question in dispute, as to the possibility of so manipulating and inclining the surface or portions of the surface of a similarly descending body, so as to prolong the gliding motion, and convert it into one obedient in some degree to the will of the operator. When the two antagonistic

forces, gravity and atmospheric resistance, are brought into operation, the result is a course, arrested and diverted in some direction, either by what we call accident, or design.

Hitherto, as in the case of the parachute, accidental circumstances have alone determined the deviation.

It has been the great desire of man for ages to supply, either in his own person, or by the aid of apparatus, or by self-acting machinery, the third requirement for flight, viz. force, which may enable him to impel a plane surface at the proper angle of inclination against the air, and thus to nullify the effect of gravity.

Necessarily, the relative proportion of sustaining surface to weight, and of power to uphold and propel that weight, have occupied much attention. Considerable misconception has existed upon these two points, and to this is mainly due the tardy progress of the science of aëronautics. In England, the subject has really never engaged the attention of scientific men, except under the form of aërostation, in the earlier years of its discovery.

There have ever been persistent believers, and experimenters, and in the influential association which has been organised under the name of the Aëronautical Society of Great Britain, embracing amongst its supporters some of the first scientific men of the day, with the Duke of Argyll as President, the subject of aëronautics has been elevated into a science.

The "Papers" read at the meetings of this Society, held at the Society of Arts, have contained much that is novel and suggestive, and evidence the fact, that scientific men have at length entered upon this wide field of discussion. In a paper by M. De Lucy of Paris, translated from the French by Dr. Cornelius Fox for the Aëronautical Society, there is detailed the result of actual experiments made by the author, with a view of determining the extent of wing surface to the weight to be sustained, and of the force requisite to raise and impel in horizontal flight.

It will assist in rendering interesting the description of several designs lately exhibited at the Crystal Palace, if some of M. de Lucy's statements and deductions are more widely disseminated.

This author asserts, that there is an unchangeable law, to which he has never found any exception, amongst the considerable number of birds and insects, whose weight and measurements he has taken, viz. that the smaller and lighter the winged animal is, the greater is the comparative surface. Thus in comparing insects with one another: the gnat, which weighs 460 times less than the stag-beetle has 14 times greater relative surface. The lady-bird which weighs 150 times less

than the stag-beetle, possesses 5 times more relative surface, &c. It is the same with birds. The sparrow which weighs about ten times less than the pigeon, has twice as much relative surface. The pigeon which weighs about eight times less than the stork, has twice as much relative surface. The sparrow which weighs 339 less than the Australian crane, possesses seven times more relative surface, &c. If we now compare the insects and the birds, the gradation will become even much more striking. The gnat, for example, which weighs 97,000 times less than the pigeon, has 40 times more relative surface; it weighs 3,000,000 times less than the crane of Australia, and possesses relatively 140 times more surface than this latter, which is the heaviest bird the author had weighed, and it was that which had the smallest amount of surface, the weight being 20 lbs. 15 oz. 2¼ dr. avoirdupois, and the surface (referred to the kilogramme 2 lbs. 3·27 oz.) 139 square inches; yet of all travelling birds, they undertake the longest and most remote journeys, and, with the exception of the eagle, elevate themselves highest, and maintain flight the longest.

M. de Lucy remarks, that if the law of surface in inverse ratio to weight be regarded, the cause of all the errors which have been committed will be readily understood; for a mathematician who should select as his type an excellent bird of flight such as the swallow, by ascertaining its weight and surface, will apportion nearly one mètre or 1,550 sq. in. to the kilogramme, and consequently 75 mètres for a man of 75 kilogrammes, that is to say, about 165 lbs. would require a surface of 116,250 sq. in. Should he select the pigeon, he will arrive at a result quite different, because the pigeon being heavier than the swallow has a surface relatively smaller. According to this type, he would arrive at the conclusion that only 20 mètres of surface or 31,000 sq. in. would be requisite for a man of the same weight.

With regard to the crane of Australia, the weight of one of which was 20 lbs. 15 oz. 2¼ dr. avoir., possessing a surface of only 1,324 sq. in., this third example would give to a man of the before-named weight a surface of no more than 10,850 sq. in.

Again, should he select a type amongst insects, for example the blue dragon-fly whose flight is so rapid, he would discover the weight to be rather more than ½ grain, and surface nearly ⅝ of a square inch, which referred to the selected standard of comparison would give 9,416 sq. in. and for the man 705,800 sq. in.

Were we to determine the amount of sustaining surface requisite for the man from some of the butterfly tribe, whose wings are so prodigiously expanded in comparison with their weight, we should arrive at results so much in excess of these

dimensions that the construction and manipulation of the apparatus would be impossible.

The author next proceeds to state that "The law of surface, in inverse ratio to weight, would naturally tend to lead us to this conclusion—viz., that the heaviest-winged animal, having the least surface, ought in return to possess the greatest force."

M. de Lucy then proceeds to disprove this assumption, by showing, that the muscular force of insects is much greater than that of birds, and he adduces various well-known instances in proof of his assertion. Upon the supposition that his facts, and the theory founded on them, are correct, it will be a fair hypothesis to assume that where large wing-surface is given to insects, the provision is accompanied by the relative power to control it, in compensation for absence of weight, which we have seen is during descent a power of itself, and is taken advantage of by some birds, in gliding, or soaring against a breeze. For such purposes, weight is a necessity, and therefore we never see any similar method of flight in the winged insect tribe.

Amidst the variety of contending theories, which have ever clothed the subject of aviation with mystery, it seemed most desirable to descend to the quieter field of practical effort, and to test the experience of those few and isolated workers, who, distributed about the civilised earth, had put their ideas into recognisable shape.

It was desired to ascertain, as the foundation of future proceedings, to what extent knowledge had been acquired, and applied, and at one collective glance, to review the whole question of aëronautics, as a *point d'appui* for further efforts.

The limited publication of this intention, on behalf of the Aëronautical Society, produced a large correspondence from all parts of the world, and also a notification of many intended exhibitors, who had reduced their theories into practice, but, and in proof how much the study of aëronautics has been pursued by persons of limited means, many were deterred from taking part in the exhibition from considerations of pecuniary outlay. The Aëronautical Society itself partakes of this disadvantage, and labours hard against a tide which has been flowing for a long period, but which, owing to the Society's persistent efforts, and the practical character of its discussions, may be said to have reached its ebb, so that henceforward it may run with the stream of Popular Science.

The first recorded and scientifically based attempt to connect plane surface, and weight, in relative proportion to one another, was that of which all the world was cognizant in 1842, patented by Henson. The plan resulted from conversation between Henson and Stringfellow at the residence of the latter-named gentleman in Chard, Somerset. Should any one reading "Astra

Castra," by Christopher Hatton Turner, a work devoted to the history of aëronautics, come to the conclusion, that Henson's aërial machine was ever constructed of the dimensions there stated, he would be in error. The passage alluded to, is extracted from Newton's "Journal of Arts and Sciences," and is as follows:

"The amount of canvas or oiled silk necessary for buoying up the machine, is stated to be equal to one square foot for each half pound weight, the whole apparatus weighing about 3,000 lbs., and the area of surface spread out to support it, 4,500 square feet in the two wings, and 1,505 in the tail, making altogether 6,000 square feet."

The fact is, that this machine was never constructed; for after two abortive attempts to manufacture models, at the Adelaide Gallery, which should represent the dimensions before-named, he rejoined his friend at Chard, and the two together commenced their experiments under a variety of forms. Mr. Stringfellow frequently availed himself of the express train, taking with him an arrangement for testing the resistance of different angles against the air, at high speed, and he states that those experiments only tended to prove, that any guess-work was better than the calculations hitherto made by writers on the subject.

However, in 1844, they together commenced the construction of a model; Henson attending chiefly to the wood or framework, and Stringfellow to the propulsive power, for which, after trial of other effects, he adopted steam. This model, completed in 1845, measured twenty feet from tip to tip of wing, by three and a half feet wide, giving seventy feet of sustaining surface in the wings, and about ten more in the tail. The weight of the entire machine was from twenty-five to twenty-eight pounds.

As pictorial illustrations of this machine were widely published at the time, it is not thought necessary to reproduce them, especially as a succeeding attempt, hereafter depicted, bears a great resemblance to it; the important difference existing in the improved method of construction. The principal feature was the very large sustaining surface in proportion to the weight, which, as we have seen in reference to M. de Lucy's experiments, was far in excess of the requisite conditions. To support this weight, it was necessary to propel the plane surface at an angle against the resisting air, and it is evident, that in proportion as the speed imparted was increased, so might the angle be decreased.

It was necessary to provide initial force; accordingly, an inclined plane was constructed, down which the machine was to glide, and it was so arranged that the power should be maintained by a steam engine, working two four-bladed propellers,

each three feet in diameter, at a rate of 300 revolutions per minute.

A tent was erected on the Downs two miles from Chard, and for seven weeks the two experimenters continued their labours —not, however, without much annoyance from intruders. In the language of Mr. Stringfellow, "There stood our aërial protégée in all her purity—too delicate, too fragile, too beautiful for this rough world; at least, those were my ideas at the time, but little did I think how soon it was to be realised. I soon found, before I had time to introduce the spark, a drooping in the wings, a flagging in all the parts. In less than ten minutes the machine was saturated with wet from a deposit of dew, so that anything like a trial was impossible by night. I did not consider we could get the silk tight and rigid enough. Indeed, the framework altogether was too weak. The steam engine was the best part. Our want of success was not for want of power or sustaining surface, but for want of proper adaptation of the means to the end of the various parts."

Many trials by day down inclined wide rails showed a faulty construction, and its lightness proved an obstacle to its successfully contending with the ground currents.

Shortly after this, Mr. Henson left England for America, and Mr. Stringfellow, far from discouraged, renewed alone his experiments. In 1846 he commenced a smaller model for indoor trial, and, although very imperfect, it was the most successful of his attempts.

The accompanying illustration (Plate XXXVI. fig. 1) is taken from a photograph. It will be observed that the sustaining planes were much like the wings of a bird. They were ten feet from tip to tip, feathered at the back edge, and curved a little on the under side. The plane was two feet across at its widest part; sustaining surface, seventeen square feet; and the propellers were sixteen inches in diameter, with four blades occupying three-fourths of the area of circumference, set at an angle of sixty degrees. The cylinder of the steam engine was three-fourths of an inch in diameter; length of stroke, two inches; bevel gear on crank shaft, giving three revolutions of the propellers to one stroke of the engine. The weight of the entire model and engine was six pounds, and with water and fuel, it did not exceed six and a half pounds.

The room which he had available for experiments did not measure above twenty-two yards in length, and was rather contracted in height, so that he was obliged to keep his starting wires very low. He found, however, upon setting his engine in motion, that in one-third the length of its run upon the extended wire, the machine was enabled to sustain itself; and upon its reaching the point of self-detachment, it gradually

rose, until it reached the further end of the room, where there was canvas fixed to receive it. It frequently, during these experiments, rose after leaving the wire, as much as one in seven. At the request of the then proprietor of Cremorne, Mr. Ellis, who with two others went down to Chard to see the machine, Mr. Stringfellow repaired to those gardens with the two models, but it seems that not much better accommodation was afforded than he possessed at home. It was found that the larger model (Henson's Patent) would run well upon the wire, but failed to support itself when liberated. Owing to unfulfilled engagements as to room, Mr. Stringfellow was preparing for departure, when a party of gentlemen, unconnected with the gardens, begged to see an experiment, and finding them able to appreciate his endeavours, he got up steam pretty high, and started the small model down the wire. When it arrived at the spot where it should leave the wire, it appeared to meet with some little obstruction, and threatened to come to the ground, but it soon recovered itself, and darted off in as fair a flight as it was possible to make, to a distance of about forty yards, further than which it could not proceed.

Having now demonstrated the practicability of making a steam-engine fly, and finding nothing but a pecuniary loss, and little honour, this experimenter rested for a long time, satisfied with what he had effected.

The subject, however, had to him its special charms, and he still contemplated the renewal of his experiments at some future day, but, he writes, "it is doubtful if that day would ever have arrived, had not you (the writer) perseveringly called me into action." The proposed exhibition of the Aëronautical Society, roused once more his old energies.

In a paper read by Mr. F. H. Wenham, at the Society of Arts, on the occasion of a meeting of the Aëronautical Society, there occurred the following observation. "Having remarked how thin a stratum of air is displaced beneath the wings of a bird in rapid flight, it follows, that in order to obtain the necessary *length* of plane for supporting heavy weights, the surfaces may be superposed, or placed in parallel rows, with an interval between them. A dozen pelicans may fly one above the other, without mutual impediment, as if framed together; and it is thus shown, how two hundredweight may be supported in a transverse distance of only ten feet."

Mr. Stringfellow eagerly grasped this idea and set about constructing the model which he exhibited at the Crystal Palace. The writer confesses to the feeling of disappointment which he experienced, upon his first introduction to this otherwise elegant little design. He had imagined, that the surest road to success, was that, by which a triumph had been previously achieved.

Mr. Stringfellow himself says, "With respect to the superposed planes, I consider they are the most practical arrangements hitherto proposed, for machines on a large scale, but I had always my doubts if they would be effective in a small model on account of their nearness to each other."

Fig. 2 (Plate XXXVI.) is from a photograph of Stringfellow's aërial machine which ran suspended from a wire in the nave of the Crystal Palace, June 1868.

It contained in its three planes, a sustaining surface of twenty-eight square feet, besides the tail. Its weight, with engine, boiler, fuel, and water, was under twelve pounds.

It possessed in its steam-engine one third of the power of a horse, and its weight was only that of a goose.

It will be seen, therefore, that the sustaining surface was more than two feet to the pound, always supposing that the system of superposing the planes, was efficiently represented in so small a model, which may reasonably be doubted. This proportion of weight to surface is more than double that, which is generally allowed to be necessary. The necessity, however, for providing even for as little as one pound for every square foot, would not exist if a certain speed could be maintained.

It was always Mr. Stringfellow's intention to set this model off free in the air, when the requirements of the exhibition were satisfied, but it was found that the engine, which had endured much work, required repairs. It had been observed by several reporters for the press that the model showed a decided tendency to an upward course during its hundred yards run at the Crystal Palace, and anxious to see it afterwards liberated, the writer assisted to hold the canvas which should check its fall.

The space at hand for the horizontal wire was small, and did not allow of sufficient speed being attained, before its liberation by a simple mechanical action. When freed from its support it descended an incline with apparent lightness, until caught in the canvas, but the general impression conveyed was this—that had there been sufficient fall, it would have recovered itself, and proceeded onwards.

Subsequently, Mr. Stringfellow lengthened the propellers, and added nine feet to the central plane, which, with other alterations, decidedly deteriorated its aërial capabilities.

He is now engaged in experimenting with a view of ultimately constructing a large machine that would be sufficient to carry a person to guide and conduct it. On this scale he would avoid many difficulties which are inseparable from small models.

As Mr. Stringfellow gained the prize of 100*l.* for "the lightest steam-engine in proportion to its power," and as the engine which propelled the model at the Crystal Palace differed from that but in dimensions, it will only be necessary to append

the following description of the steam engine, which was given in the Report upon the Exhibition published by the Aëronautical Society: "The steam engine does not differ from an ordinary one, except in the precautions to ensure lightness. The two-inch cylinder is of very thin brass tube; the covers, flanges, and glands are also as light as can be made, consistently with strength; the ports and passages are in one separate piece, screwed on; the piston-rod passes through each end of the cylinder, and by means of long connecting rods, works in opposite directions two cranks, fitted to the axes of two four-bladed screws, three feet in diameter; two light bars extend from the crank-shaft down each side of the cylinder: these sustain the thrust of the piston, and a framing is thus almost dispensed with. The boiler consists of a number of inverted cones, made of very thin sheet copper, with the joints soldered with silver solder. Each cone is closed with a hemispherical cap. The cones are placed in parallel rows; the bottom ends, or apexes, of the series are all connected together by water-tubes; and from the hemispherical tops a small steam pipe conveys the steam away to a cylindrical chamber above the system: this is set in the smoke-box, and serves as a super-heater, and the steam is quite dried therein. The cones are not liable to prime, as the water surface for the escape of the steam is extensive, and the steam rises clear from the generating surfaces. The fire space between the bases being large and free, this form of boiler is particularly well adapted for burning liquid fuels. The question may be asked, Is there not some hazard in employing metal almost as thin as paper for sustaining pressures exceeding 100 lbs. per square inch? But it is well known that in the so-termed 'tubulous' boilers, to which class this one belongs, if a rupture takes place in one of the elements, a gradual and harmless escape of water and steam is the only consequence; this empties the boiler by degrees, and at the same time ends the danger by extinguishing the fire, thus differing in character to the explosion of a boiler, whose strength depends upon the external shell, the fracture of which causes instant destruction, both to itself and all within its vicinity."

The cylinder is two inches in diameter, stroke three inches, boiler pressure 100 lbs. per square inch. The engine makes 300 revolutions per minute. In three minutes after lighting the fuel, the pressure was 30 lbs.; in five minutes, 50 lbs.; and in seven minutes it attained its full working pressure of 100 lbs., driving two four-bladed screw propellers, three feet in diameter, at 300 revolutions per minute.

In an article entitled "Swimming or Flying," contributed to the *Times*, and published April 9, 1868, signed "The Apteryx," the author comments upon the possibility of man's sustaining

himself by his own muscular exertion, and especially refers to Mr. Charles Spencer's assertion that he could not only effect this feat, but that he could sustain flight for several yards.

In opposition to this assertion, he says "A gymnast who lifts weights, and who has supported his own weight on his arms, on wide-set parallel bars, must conclude that the feat announced for June is simply impossible, for no acrobat could lift and sustain himself in the attitude of a spread eagle, by beating the air long enough to move the distance. If this aëronaut flaps at all, he will come to grief, like the sage in Rasselas, and like all others who have tried flying with artificial wings."

Mr. Spencer is acknowledged to be one of the best teachers of gymnastics in this country, and he is himself no mean performer. His experience upon the trapèze induced in him the belief that it would not require so much proportion of plane surface to support a given weight as is generally supposed.

He accordingly constructed an apparatus, and by its means he avers that he has proved, that 110 square feet properly disposed, is sufficient to sustain 158 lbs. weight. With such an apparatus, composed of plane and wings, he states, that running down a small incline in the open air, and jumping from the ground, he has by the action of the wings, sustained flight to the extent of 120 feet.

The framework of this apparatus, exhibited at the Crystal Palace, was a marvel of lightness and strength, composed of steel umbrella wires and wicker work. In attempting to improve upon a previously constructed design, the material with which he covered it, was found to be too fragile, but he states that on practising in the transept of the Crystal Palace—the apparatus being suspended from the roof by a rope—he was able to raise himself by the action of the wings. Fig. 2 is from a photograph of the apparatus. The tail is here denuded of its covering. Length of tail, 18 ft.; width at the end, 8 ft.; depth of keel at the end, 4 ft.; weight of tail, 15 lbs.; area of tail, 72 sq. ft. Length of wing, 7 ft.; width at the widest part, 4 feet; area, 15 sq. ft.; weight, $1\frac{1}{2}$ lb.; weight of the whole tail, 15 lbs.; wings, 3 lbs. = 18 lbs.; weight of himself, 10 stone, and sustaining surface, 110 sq. ft.; total weight of himself and apparatus, 158 lbs.; making not quite $1\frac{1}{2}$ lb. to the square foot.

Owing to the wicker-work—which is made to fit tight round the body—causing pain, and otherwise obstructing his movements, he was unable to satisfy the curiosity of the public, and he is now reconstructing that portion, and substituting a stronger material for the covering.

According to De Lucy's theory of surface in inverse ratio to weight, the sustaining surface, instead of being 110 square feet, need only have been about 31 square feet, always supposing

that the surface was effectively disposed, which in Spencer's apparatus may be very properly questioned.

Want of space, however, precludes any attempt to pursue this question further.

We come now to the description of another machine exhibited, the invention and construction of Wm. Gibson, a working man of Outram Street, West Hartlepool.

Dissimilar to either of the former inventions, which respectively consisted of plane—and plane with wings—this was expected to obey the action of the wings alone.

The mechanical action at the command of the operator was intended to be controlled by the downward pressure of each leg alternately, assisted by the arms.

The machine therefore consisted of a framework, to which were attached four wings, so that by pressure upon one treadle, two flew up feathered, and two descended with an impact upon the air, as in Fig. 4, where the two lower wings are in the act of ascending.

In a previously constructed apparatus provided with two wings only, Gibson states that a man weighing 10½ stone repeatedly raised himself from the ground from 12 to 18 inches, but that he could not sustain himself, because the wings being so heavy, he was not able to repeat the stroke. Each wing was 12 feet long, 1½ feet across at the wider part, and 1 foot at the narrower; surface of both wings 37 square feet; weight of each wing, 10 lbs.; frame and rods, 21 lbs.; weight of man, 10½ stone; giving about 5 lbs. to each foot of sustaining surface, a condition which severely tests the theory of inverse proportion of surface to weight.

The four-winged contrivance sent to the Crystal Palace was found to be too heavy for trial, but the inventor's enthusiasm seems to be quite equal to the construction of another and lighter apparatus for further exhibition.

It must be remarked as an interesting feature in Gibson's apparatus, that the total weight of the man and apparatus, as compared with the surface, gives on De Lucy's theory, about 38 square feet as the proper sustaining surface, or one foot more than it possesses—taking for our calculations, the Australian crane, and the theory of inverse proportion with its margin of from eight to ten times.

Experiments can alone determine the true path to success, and it is encouraging to find that these are now aiding in the determination of the question. It is possible that we may shortly witness some more advanced attempts, and should they prove to be failures in the practical solution of the problem, it will perhaps be remembered that previous failure having led to increased knowledge, so future success may result from their repetition.

THE COMPOUND EYE OF INSECTS AND CRUSTACEA.

By HENRY FRIPP, M.D.

THE anatomy of the insect eye, as described in recent treatises and manuals enjoying a wide circulation, is little more than a repetition of observations made by Swammerdam,* Murcel de Serres,† Strauss Durkeim,‡ Dugès,§ and Johann Müller.‖ For the most part, also, the accompanying illustrations consist of unaltered copies of figures drawn when microscopic anatomy was in its infancy. Consequently, text and illustrations date alike from a period when the nature of the terminal elements of the optic nerve fibres was entirely unknown, and the histology of the several component structures of the eye but very imperfectly understood.

From the dates given below, and from the recital of the same authorities, and the same meagre details of the anatomy of the compound eye, the reader might naturally conclude that no later discoveries had been made, or that no further examinations had been attempted. That this is far from being the actual state of things, we hope to be able to show in the following pages, wherein the results of certain interesting researches, prosecuted by Professor Leydig in Tübingen and by other anatomists, will be recorded. Yet it must be admitted that our acquaintance with the structure of the insect eye, and with the true character

* "Bibel der Natur" and "General History of Insects," 1663 (two centuries ago!).

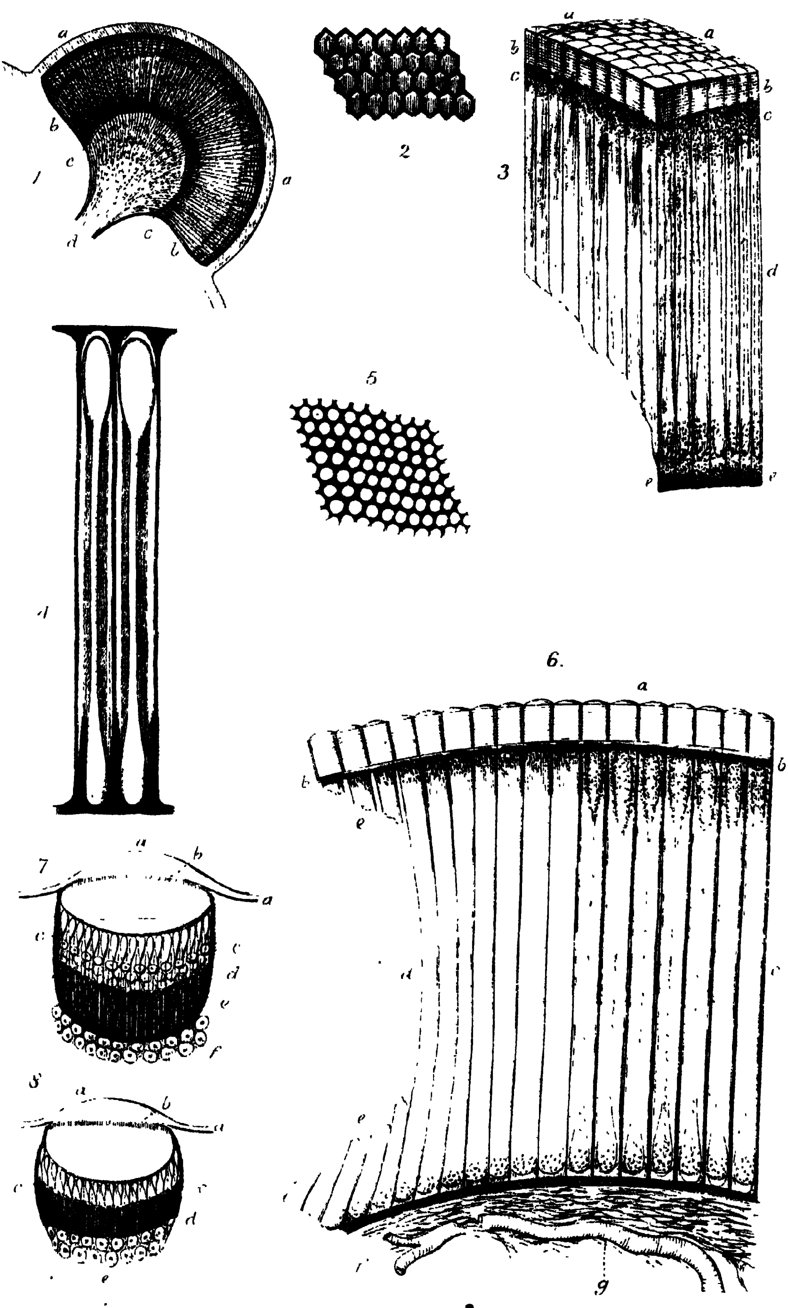
† "Mémoire sur les Yeux composés et les Yeux lisses des Insectes." 1813. Montpélier.

‡ "Considérations générales sur l'Anatomie comparée des animaux articulés, auxquelles on a joint l'Anatomie descriptive du Melolontha vulgaris." 1828. Paris.

§ "Observations sur la structure de l'Œil composé des Insectes." 1830. Annales des Sciences.

‖ "Zur vergleichenden Physiologie des Gesichts-Sinnes." 1826. Also Memoirs published in "Annales des Sciences," tom. xvii. and xxii.; also "Handbuch der Physiologie des Menschen." 1840. Leipsic. "Zeitschr. f. Physiol." Bd. iv. 1832, &c. &c.

Plate XXXVII



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Compound Eyes of Insects

of insect vision, has ripened but slowly during the last thirty years: that is to say, since the publication of the researches of Johann Müller, in his great work on the Physiology of Man.

Within the same period, it is true, our knowledge of the vertebrate eye has been greatly perfected and extended, as indeed was to be expected. Firstly, because our recognition of the conditions under which the act of vision is performed by the vertebrate organ is founded upon our own personal experience of visual phenomena, which necessarily affords a closer insight into their nature and causes than can be gained by observing the act of vision in the lower animals, whose apparatus of sight differs in mechanism and in mode of action, with which we cannot familiarise ourselves, as in our own case, by the aid of subjective sensation. Secondly, because, in addition to this empirical knowledge, the necessity of an intelligent acquaintance with the structure of an organ so essential to our well-being operates as a constant spur to scientific investigation. Hence, also, the study of physiological optics has been pursued with the same aim, and in a similar direction: that, namely, which chiefly concerns the physical and psychical conditions pertaining to the function of vision as exercised in the so-called "vertebrate type" of eye.

Long and laborious researches into the structure and function of the vertebrate eye have finally been rewarded by the happiest results. For, beside that accurate conception of the seeing faculty, and that rational explanation of the visual apparatus, which is so important and satisfactory in a scientific point of view, we have gathered precious fruits for the service of humanity, in the many curative methods to which such knowledge has led the way.

On the other hand, the practical interest attaching to the study of the eye structures in the lower animals decreases in proportion as the apparatus resembles less and less the type of visual organ possessed by man. And the labour of investigation falls, in this as in every other enquiry of a purely scientific character, on those who are content to pursue knowledge for its own aims and ends, and to accept every step in advance as sufficient compensation for their labour. Once attained, however, the triumph of this knowledge belongs to and is participated by many who follow with lively interest the general progress of science. To the readers of our Review we may therefore, with some confidence, offer a short summary of researches on a subject of great interest to all students of natural history.

The mechanism of the eye as seen in the vertebrate animals presents such an obvious relation to its mode of action, that a person accustomed to look upon this particular plan of construction as the only one by which vision can be accomplished

will be struck with astonishment when he discovers, on further examination, that an extraordinary variety of structural arrangements obtains in the descending scale of animals. In complicity and minuteness of detail the vertebrate eye surpasses all others. Yet in so far as optical laws postulate a certain arrangement of the eye structures it might be said to explain itself: that is to say, the actually existing disposition of transparent refracting media is just such as might be imagined *à priori* as a consequence of known laws of light transmission, and known properties of matter. With such conceptions of plan and principle in his mind, the observer cannot but feel perplexed with the apparent contradictions which he meets with, when he examines the structure of the eyes of the lower invertebrata. The seemingly simple plan of the mammal eye loses itself in a wondrous diversity of external form and internal structure. In one case, elements considered to be essential are apparently missing; in another, additions are found which have no counterpart in eyes supposed to be more perfect. And a comparison of extreme instances would lead to the inference of a total irreconcilability of constructive plan, and even to the suspicion that the function can scarcely be one and the same in each case, were it not that organs of an intermediate character are found in the several classes of animals, which supply connecting links, and enable us to trace a continuity of really essential parts, and a constancy of fundamental conditions, throughout the whole series. The final result of this comparative method of study is highly interesting and important: namely, that the same laws which have been found to obtain in the rationale of human vision, equally apply to every creature possessing a faculty of sight, which amounts to perception of form and colour. Just as the observed perturbations of the calculated movements of distant planets, instead of upsetting the doctrine of an universal law of gravity, triumphantly confirm it, by the discovery of new heavenly bodies, new elements of calculation by which the previous errors receive due correction, so do the unexpected and startling contrarieties of structural arrangement in the eyes of different animals eventually lead to the fuller proof of principles seemingly jeopardised by unsuspected complications. So again the inseparable connection between every known kind of eye and the phenomena of light transmission (and such phenomena are as universal and fundamental as those of gravitation) compels us to receive with implicit confidence the surprising evidences of this mutual relation of the eye to light, and light to the eye, incidentally afforded by the discovery of fossilised corneal structures of marine animals living in remote ages, but now extinct. Thus a microscopic fragment of rock may reveal to us facts respecting the

physical conditions of organic matter, and the physiological laws of animal sensation, which obtained on the surface of our globe at a time when no human eye had been formed; and this with as much mathematical certainty as if we were drawing conclusions from the preparations of insect and crustacean eyes lying on our table, or studying diagrams from the latest work on physiological optics.

The term "compound," as applied to the eyes of articulata, is at once significant of the most important modifications of structure met with in these animals, and of the most remarkable differences of opinion held by physiologists respecting the *modus operandi* of the organs in question. An entirely satisfactory definition of the compound eye is, therefore, scarcely possible, so long as its structure and function remain subject to dispute on all sides. As it is advisable to avoid entering into a controversy which still agitates the scientific world, and to limit our remarks as far as possible to the positive (i.e. the anatomical) side of our subject, we shall content ourselves with a very brief reference to the general doctrines which bear on the explanation of the several modes of vision.

To place our readers properly *en rapport* with the doctrine at present held respecting the vision of animals possessing compound eyes, we must advert to the theory propounded by J. Müller, and still almost universally taught: namely, that the type of construction (and the optical principle on which it is based) differs radically from that of the eye of man and vertebrates generally. The vertebrate type is represented by a hollow globe formed by membranes commonly called tunics or coats of the eyeball. The interior of this globe is occupied by a large central mass of transparent substance (the vitreous humor), in front of which is placed a crystalline lens with a moveable diaphragm or iris. Light is admitted into the interior of the eye through the front transparent portion of its outer coat (cornea), and, passing through the crystalline lens, is converged to a focus near the centre of the eyeball; but the rays cross at this point, and are transmitted through the vitreous humor in a diverging course coincident with the radii which fall upon the inner (concave) surface of the inner coat of the eye (choroid coat) from an imaginary centre, which closely corresponds with the focus of converging rays admitted through the cornea in front. At the back of the eye, where the inverted rays of light, after traversing the vitreous humor, fall on the inner coat, lies, interposed between the convex surface of the vitreous humor and the concave (inner) surface of the choroid coat, a membrane-like expansion of nerve fibres with associated elements composing the retina. This retina, therefore, is in direct contact with the rays of light that have traversed the

interior of the eyeball. And it results from the action of the several curved surfaces of the cornea and lens, and from the specific power of refraction due to the density of their substance, that an inverted image of any illumined object in front of the eye must pass through the transparent retina, and be reflected back again from the inner surface of the choroid (which is darkened by pigment) upon the retinal elements in contact with it. An optical image is, therefore, received by the retina, and *perceived* as if it were the object itself. The action of the refractive media, by which this picture of external objects is formed on the inner spherical concave of the pigmented choroid coat, is commonly illustrated by likening the whole dioptric apparatus to a "camera obscura," where the images formed by the lenses fall on a prepared surface, or, as in a photograph camera, on a ground glass plate, or the chemically sensitive surface substituted for it when a photograph is taken.

The type of construction of the compound eye is, on the contrary, *not* that of a globe filled with refractive media, nor is the retina of the compound eye spread out in membrane-like expansion over a vitreous humor. The optic nerve at the bottom of the eye swells into a large solid mass by addition of fresh nerve matter (granules, nuclei, and medullary substance) together with pigment, connective tissue, blood vessels, tracheæ, and even muscle fibrils. And this mass, known as "optic ganglion," fills the space at the bottom of the eye, presenting, as it is continued forwards to the centre of the eye, the form of a solid cone, widening towards the front. The peripheral surface of this optic ganglion is covered with a thick layer of pigment, which appears to intercept all passage of light from the front to the back of the eye. But, *through* this pigment layer, numerous nerve fibres (enclosed in sheaths of investing membrane) pass onwards in direct lines towards the cornea, but terminate in peculiar-shaped bodies situated immediately behind it (these will afterwards be more particularly described).

Thus, there is neither a central vitreous humor nor a lens answering to the crystalline lens of the vertebrate eye; nor is there apparently any retina interposed at the focal plane of a dioptric apparatus to receive and perceive images. And since it is impossible that, in an eye thus constructed, images could be formed by the passage of collective rays of light through its interior, it was supposed that the sensation of light was produced by direct contact of rays, which, falling on the cornea and passing through without refraction, met the nerve fibres behind: *but there being no focal convergence, no optical image was formed.* Such an hypothesis, however, failed to show how external objects could be seen in definite form and with distinct detail. Ac-

cordingly, another mode of vision was propounded to meet the seemingly anomalous conditions and deficient mechanism of the dioptric apparatus. This new theory was based on the fact, since proved to be erroneous, that the minute facets of the compound cornea presented perfectly flat surfaces, without and within, and that, although the general curve of the cornea rendered such eyes capable of a very wide field of vision, no collective image of objects was produced by lens action. Each separate facet was supposed, therefore, to admit only a central pencil of rays, which, penetrating in direct lines, reached the ends of nerve fibres from the optic ganglion, and produced separate impressions. That is to say, no optical image was perceived; but as we see a pattern in mosaic composed of numerous inlaid pieces, so the image of an external object was supposed to be made up of the separate impressions caused by rays of light proceeding from the illumined points of the object seen. The concurrence and combination of these separate impressions into a picture, formed as it were by the mind's eye, is therefore a retinal or cerebral function rather than an optical phenomenon brought to pass by physical means.

To such a theory insurmountable objections present themselves. Anatomical facts, as now interpreted, contradict it; optical phenomena, long known but not sufficiently kept in view, disprove it; physiological reasonings based on the study of the true analogies and homologies of the constituent parts of the eye compel us to reject it; and, lastly, direct observation of the living organ indicates the closest possible approach to the same mode of vision in all eyes possessing a true retina.

The hypothesis of a double type of construction and function of the simple and compound eye was, at the time of its promulgation, supposed to be founded on anatomical facts. But these were, to say the least, very imperfect and too limited for so wide-reaching a generalisation. In so far as the word "type" may be meant to indicate the existence of important structural modifications (not, however, subversive of the law of unity of means and purpose), there may be said to be many types of eye structure. Strictly speaking, however, they are but variations of one fundamental scheme, and cannot be considered as distinctive characteristics of the respective provinces of vertebrate and invertebrate animals: for, in point of fact, the chief variations are found in the latter only. In comparing the ascending series, a certain progressive complicity of the retinal structure is sufficiently remarkable, but its essential character is the same throughout. In respect to the dioptric apparatus, greater divergence of plan is apparent in the compound eye; but this is strictly in accordance with the variation of retinal development. But the reason of such modifications is rather to be

sought for in the particular organisation and habits of the animal than in its place in the animal series. In the insect the compound eye presents us with the solution of a truly wonderful problem: namely, the construction of an apparatus of vision surpassing in accuracy and perfection that of multitudes of creatures superior to it in other attributes, yet with so little expenditure of material as not to burden its diminutive and buoyant body or interfere with its powers of flight. And when we remember that its most rapid motion is still guided by a sight so keen as to precede muscular action, we cannot avoid the conclusion that its faculty of seeing is adapted to its habits of life, without any reference to its position in our artificial classifications.

If, then, it be admitted that our conception of a seeing faculty should be physiologically one and the same for all organs of sight; if, also, the variations of anatomical structure can be reduced to one fundamental scheme of construction, it follows that we shall best understand this by tracing the points of identity and similarity of parts and functions than by exaggerating apparent differences, and finding in these a proof that Nature, in arranging an organ of sight, has departed from her usual singleness of aim and means.

Now the fundamental principle may be stated thus: the production by physical means of an optical image of external objects; and the direct contact of percipient nerve elements with this image. And the problem which the anatomist has to solve, is to discover the constructive plan by which an optical image is produced and brought into contact with the percipient element. Whether the plane of contact be found at the back or front of the eye, the principle and the final result remain the same. The anatomical positions we take up are these. 1. The compound eye of Articulata is the ground-type of visual organ in these animals. 2. The simple eye (found with the compound eye on the same animal, as in insects, spiders, &c.), is a variety of the compound eye, and not, as J. Müller believed, constructed on the so-called vertebrate type. 3. In neither kind of eye is the physiological signification of retinal or lens apparatus so essentially distinct as to justify the hypothesis of opposed principles of optical construction or visual function.

In the details which follow we shall continue to employ the same designations for homologous parts of the insect eye as are in common use in the description of the vertebrate eye. Thus the coats of the eye will still be called sclerotic, corneal, choroid (with its appendage—iris). The dioptric structures (crystalline lens, vitreous humor), and the nerve structures (optic nerve trunk and fibres and retinal elements) will still receive the same designation wherever they are found, however modified. And first of the *Cornea*:

The general surface of the insect cornea is spherical and more or less complete according to the size of the eye. And the anterior and posterior faces of the compound cornea are as a whole parallel (see Plate XXXVII. fig. 1, Plate XXXVIII. fig. 9). But in many insects (see figs. 3, 6, dragon-fly) the anterior surface is partitioned into a varying number of minute facets—four-sided in crustacea, six-sided in insects (with unimportant exceptions). The number and shape of these are however of little significance, for four- and six-sided facets may be seen on the same cornea, whilst in beetles, butterflies and other insects a deposit of pigment at the angles formed by the sides leaves only a central circular clear space for transmission of light. A fact far more important is the convex lens shape of the anterior or posterior faces of the facetted cornea. This convexity is most strongly marked on the posterior faces. On the anterior face it is mostly slight (fig. 15, Hymenopterous insect, figs. 3, 6, dragon-fly, show it more distinctly). On the posterior surface corresponding to facets in front, the curve is often almost hemispherical (see figs. 13, 14, Coleopterous insects); but it is not so strong in Diptera (common fly) or in Hemiptera (notonecta). In beetles an anterior and posterior curve is found. In certain crustacea (Herbstia, fig. 12, Ilia, Lambrus) the posterior curve is strong, but in the cray-fish (fig. 9) it is flat. Without multiplying examples, it may be stated that the corneal facets of almost all insects present either an inner or outer curve, sometimes both. The optical significance of this fact is all-important; for it follows that every corneule * of a compound cornea produces a distinct focal convergence of rays, just as a plano-convex or double convex lens does. That is to say, an optical image is formed by each corneule, and on looking through a piece of compound cornea we see as many separate images as there are facets. Thus, an old writer remarks, on looking at a man through a piece of insect cornea we see an army of dwarfs! Under such circumstances "mosaic vision" (see *ante*) is simply impossible.

But how does the case stand with the simple insect eye? J. Müller was led by his investigations to conclude that the simple insect eye closely resembled the eye of a fish. He describes the corneal surfaces as being plain, with their outer and inner faces parallel: behind this a globular crystalline lens, which however he expressly states to be adherent to the posterior surface of the cornea. Later researches have shown this description to be erroneous. The large globular "lens" of the simple eye is

* This term is employed to denote each small segment of corneal substance corresponding to a facet and lying between the anterior and posterior boundaries of its thickness. The corneule is at once understood by looking at the section of a cornea.

really a projection of the inner corneal lamellæ: an excrescence, so to speak, of corneal substance: in fact, an exaggerated form of the *inner* curve of the corneule of the compound eye. M. Dujardin has well proved this in a memoir published in "Annales des Sciences," 1867; and Leydig has given figures showing it (figs. 7, 8). The cornea lenses therefore of the simple and compound eye are not exactly the same as the crystalline lens of the vertebrate eye. But they perform the same function and rank as analogous parts. The crystalline lens of the vertebrate eye is indeed developed from cuticular cells, and though a more perfectly differentiated structure, and separated from the cornea (which is also a cuticular mass metamorphosed into chitin in the insect eye, while in the vertebrate eye it retains traces of its cellular origin), is homologically almost identical with the corneal lenses of insects. Thus, one of the most striking differences between the two types is on closer examination reduced to a variety of the same structural elements, the essential character of its functions being identical.

The result of this variation in the disposition of corneal lenses is certainly remarkable: for in the compound eye a multiplication of images is the consequence of its facetted arrangement, whilst in the simple eye a single large corneal lens admits of the focal concentration of collective pencils of light upon the nerves behind it. Where, however, simple eyes (which are much smaller than the compound eye) are grouped together in one spot commanding the same field of vision, multiplication of images must occur so that the optical phenomena are similar. The reduction of multiple images into one mental picture is, however, a fact common to all animals, and not simply characteristic of the invertebrate eye. Single vision with two eyes is the most obvious and striking fact in our own experience.

Respecting the structure of the cornea little need be added. It is chitinised skin, or rather epidermis, its original cell elements being lost during the process of metamorphosis. The cornea shows nevertheless traces of a lamellar structure, as indicated by the fine horizontal lines running parallel with the surface (see figs. 3 and 6). Vertical lines more strongly marked (see same figs.) divide the cornea into vertical segments, the anterior and posterior faces of which are bounded by the plane or curved facets, and each segment thus bounded is conveniently designated a corneule. Fig. 2 shows a surface view, and fig. 6 a section in which the curve of the exterior facet is well seen: the interior facet is in this instance a plane surface, and therefore the whole posterior surface of the cornea forms a continuous smooth curve. In different insects the thickness of the cornea varies greatly. Figs. 13 and 14 show a thick cornea with flat front facet and convex inner facet (plano-convex lens). Figs.

15 and 16 show a thin cornea with both faces slightly curved (double convex lens). Fig. 12 shows a thin cornea with flat front facet and half-round inner facet. Fig. 11 shows a thin cornea with flat outer and inner facets. All these varieties stand in close connection with the particular disposition of the parts lying under the cornea. Sometimes (but rarely) the two facets form a meniscus, the front facet curving outwards, and the back facet having a slighter curve directed the same way (i.e. it appears concave when seen in section).

Before entering into the details of the underlying parts we must direct attention to their general disposition and relation. Fig. 1 is a section through the central plane of the dragon-fly's eye. The double outline of the cornea sweeps in a regular curve continuous with the chitin skin (the figure is not sufficiently magnified to show the small facets). Immediately behind the cornea (already fully described) a dark shade represents a mass of pigment, which causes the peculiar blackness of the eye when seen in front. No pupillary opening can be seen, as in the vertebrate eye, until a piece of cornea is placed under the microscope (with a high power objective). Then a clear opening in the very centre of each facet is observed, and the pigment around it corresponds with the iris pigment of the vertebrate eye. The colour of this pigment often corresponds with that of the insect's skin: sometimes white or yellowish white, grey, yellow grey, and so on to the deepest purple or black; and it may even possess the same metallic brilliancy observed in the iris colours of the fish, amphibian and reptilian, eyes.

Between the cornea and optic ganglion a series of radial lines (*b*) indicates what we have called the bacillar stratum, as we consider it the equivalent of that portion of the vertebrate retina known under the same name. A detailed description of this will be given below. The radial lines in our figure extend outwardly to the cornea, inwardly to the peripheral surface of the optic ganglion (*d*). This latter occupies the centre and bottom of the eye, and is composed of nerve fibres and associated elements corresponding with the retinal ganglionic layers of the vertebrate eye, though less perfectly developed.

Sclerotic coat.—Continuous with the border of the cornea and where it joins the chitin skin, a membrane (indicated in the figure by a dark line marking the posterior boundary of the eyeball) is seen, which completes the outer tunic. Even in the simple eye, small as it is, the neurilem or sheath of the optic nerve covers the optic ganglion, and is continued forwards as a delicate membrane which loses itself in the cornea. But in the compound eye of Libellula (see fig. 1) it is a stiff chitinised membrane on which muscles rest which are attached to its outer surface. At the equator oculi it conserves the globular form of

the eyeball, but at the bottom of the eye it curves in (like the cup-shaped inversion of the bottom of a wine-bottle) and separates the eye from the general cavity of the head. In a physiological point of view the existence of a sclerotic coat or capsule is unimportant; but anatomically the determination of its true homology possesses great interest, as it helps to prove the identity of constructive plan which has been so much lost sight of in comparing the vertebrate and invertebrate eyes.

Choroid and Iris.—In our figure a line of darker shading sweeping round the inner surface of the cornea and continued on the inside of the sclerotic coat and in front of the optic ganglion represents a choroid coat. This is deeply pigmented, just as we see it in the vertebrate eye; and where it lines the cornea a stroma of pigmented cells in irregular layers is very conspicuous after due preparation under the microscope. The same characteristic stroma is even more marked where the choroid lying on the periphery of the optic ganglion receives additions of pigment which line the nerve sheaths of the bacillar stratum. Thus the optic ganglion lies really outside the cavity of the eyeball. In the eyes of higher mollusca (cephalopod and pulmogasteropod) this optic ganglion is seen much more distinctly separated from the eyeball proper, although covered by a reflection of the sclerotic capsule. In the vertebrate eye the separation of the optic nerve trunk into separate bundles of fibres occurs just as it passes through the choroid coat: and in the invertebrate eye the separation of isolated fibres from the ganglion mass occurs just in the same place and in a similar manner. But in the invértebrate eye the choroid pigment, besides lining the sides of the eye, is massed in quantity in the interior, both at the bottom of the eye and in bands which run through the optic ganglion and also invest the separate nerves. And the dense pigment layer covering the outer surface of the optic ganglion for a long time misled observers into the belief that rays of light could not reach the percipient elements of the retina; whereas, as we now know, these percipient elements are situate in front of the optic ganglion, and in fact extend as far as the posterior surface of the cornea, their outer ends being in direct contact with the plane of images formed by the corneal lenses. On referring to fig. 5, which is that of a section across the bacilli (percipient elements), we see a number of clear circles, the sheaths of these bacilli, surrounded by dark lines representing the pigment on their outside. Referring again to fig. 6, we see how the outer and inner ends of these sheaths are imbedded in the thick layers of pigment accumulated behind the cornea and in front of the optic ganglion. The portion of pigment in front which subserves the office of iris covers the bulb-like or pear-shaped end of the bacillum except at its point of contact with the cornea; so

that light passing through each corneule falls upon this point and penetrates the clear refractive substance of the bacillum. The pigment surrounding the bacillum (or rather its sheath) isolates it completely, and assists the internal refractions going on in the substance of the bacillum by reflecting the rays back on the nerve.

The Bacillar stratum.—We now approach the most obscure point in the anatomy of the eye, and one which is most liable to misinterpretation, as it has proved also most fruitful of controve sy. First in order, we may take the structure of the bacillar stratum as represented in our sketch of this apparatus in the dragon-fly. Looking at the section (fig. 6), we see stretched between the cornea and the optic ganglion a series of lines which represent the membranous sheaths of a number of bacilli, some of which are shown empty, whilst in others the nerve rod is figured within. The sheath is formed of clear membrane, but pigment strongly adheres to its outer surface. On its inner surface may sometimes be seen one or more small nuclei, and histologically the sheath membrane may be considered homologous with the "connective tissue" septa found in the retina of vertebrate eyes. At its outer extremity it is continuous with the stroma of pigment cells which lines the posterior surface of the cornea and is firmly attached to the corneal substance. A clear view of this connection can only be obtained by removing the pigment with the aid of solution of potash. In fig. 6 this connection is, however, well seen at the thin end of the section. Its inner extremity is in like manner continuous with the pigment-encrusted stroma of the choroid coat which covers the periphery of the optic ganglion. Thus then a framework of tubes fills the whole space between the cornea and optic ganglion; and the nerve fibres which spring from the optic ganglion, after piercing the pigment layer of the choroid, enter at the bottom of the tubes, and are continued forwards inside the tube (or sheath) to the cornea. But these nerve fibres are not like ordinary nerves. Their substance undergoes a remarkable metamorphosis, and their form an equally remarkable change. The nerve matter becomes highly refractive and crystalline in appearance, and the form of the nerve varies greatly in different eyes. Sometimes it swells into a club-shaped mass with ridges on four lines of its outer surface as soon as it enters its sheath: then in the middle of its course it runs to a fine thread, still preserving its quadrangular shape (best seen in section): again, as it approaches the cornea, it swells a second time into an oval or pear-shaped mass which entirely loses the character of nerve substance. In other instances the nerve has no bulbous swelling below, but as it approaches the cornea swells into a four-lobed mass situate at its outer end. Some of the most characteristic forms are given in

our figures. Thus fig. 9 shows the bacillar stratum enveloped in pigment, with the curiously varied form of the single bacilli, cross sections of which in fig. 10 exhibit the cruciform disposition of its substance in different parts of its course. Fig. 11 shows the complete bacillum in detail: its club-shaped swelling below as it springs from the optic ganglion: its nerve-like thread in the middle, and its four-lobed mass (darkly pigmented) at its termination immediately beneath the cornea: also its enveloping sheath with nuclei on the inner wall. These three figures represent the structure as seen in the eye of the cray-fish. In fig. 12 (Herbstia) a still more strongly marked change of form is seen. Below, the same club-shaped expansion; then a diminished rod-like portion, which soon swells into a very distinct four-lobed mass containing nuclei in each lobe; then from the top of this a narrowed thread rises, which swells for the third time into a four-lobed highly refractive and delicate mass of transparent substance immediately under the corneal lens. The sheath closely invests this singularly shaped body, and is seen free only in the small space between its apex and the superjacent corneal lens. In fig. 14 (eye of Procrustes) the nerve is seen springing from its optic ganglion, and swelling immediately into a spindle-shaped mass (cruciform in section) which is distinctly striated: then a finer thread runs on and forms a second small four-lobed knot, from which again the nerve rises and swells a third time into a pyriform four-lobed mass which nearly touches with its apex the inner facet of the cornea. Its sheath is straight and invests the nerve loosely. Fine tracheæ run up within this sheath; and also (on the left hand) two muscle fibrillæ (!) run up within the sheath, and are lost on the membrane investing the upper four-lobed swelling. (In all these preparations the pigment is removed by solution of potash.) In fig. 13 (Dynastes) the nerve shows an elongated swelling, continued at the middle into a fine thread which ends in a small four-lobed knot, from the top of which the nerve again rises and soon expands into a terminal pear-shaped mass touching and partially embracing the inner curved facet of the corneule above it. In fig. 16 (Schizodactyla) the nerve undergoes little change of form until it approaches the cornea, where it swells into a pyramidal body. The left-hand bacillum is figured with a crust of pigment; that on the right hand is figured as it appears after the pigment is removed, by which the continuity of substance of the whole nerve structure is better shown. In fig. 4 Plate XXXVII. (Libellula) two bacilli nearly resembling in form those represented in fig. 15 (Mantis) are seen. In both the simpler form of conical swelling below and above clearly shows the anatomical continuity of the whole nerve. In fig. 18 (Acridium) the nerve rises in the middle of the sheath accompanied by muscle fibrils

which are studded with pigment: at the top of the nerve is the usual four-lobed terminal mass. In fig. 17 (Syrphus) the nerve is of nearly equal thickness in its whole extent up to the point where its ridged edges swell into a four-lobed knot embracing a trumpet-mouth shaped crystalline body at the top. Between the bacilli large tracheal tubes running from the optic ganglion up to the cornea are noticeable.

Now, as may be expected, the interpretation of this curious structure has been variously given, and is still discussed; for on the settlement of this question the explanation of vision in the compound eye rests. It is to be noted in the first place that the upper crystal-like oval or pyriform body was known and figured long before the peculiarities of form which the lower part exhibits were known. Whatever form the lower part takes, the crystal-like expansion above never fails; and, from its delicate transparency and semi-fluidity of substance, as well as on account of its position close behind the cornea, it was never till recently suspected to be continuous with the nerve rod, or considered to be nervous matter. It was, therefore, explained as an independent element, and, in virtue of its position, shape, and refractive property, was supposed to be a lens and its function analogous with that of the vertebrate crystalline lens or vitreous humor. Thus, J. Müller, who first demonstrated its constant presence in all insect eyes, but who at the same time was unaware of the equally constant lens form of the inner corneal facets, looked upon this "crystalline lens" as the analogue of that of the vertebrate eye, and assigned as its office the transmission of the central ray of light penetrating through a corneal facet to the nerve behind it. Rudolph Wagner took a different view of the matter. Observing that this crystal-like body was composed of matter of different density—namely, an inner central portion more solid and refractive, and an outer casing of softer matter—and believing that he had traced the nerve fibre behind it into the outer casing, he conceived that the inner central substance was a "vitreous humor," and the outer casing an expansion of nerve substance round it, just as the vitreous humor of the vertebrate eye is covered by the retinal expansion of nerve fibres. Accordingly, he interpreted the functions of the crystal-like body to be that of receiving rays of light from the cornea and forming an image of external objects upon its peripheral surface; that is, in direct contact with the retinal expansion of the nerve fibre. Wagner's interpretation was obviously based on analogy of the vertebrate eye, but his anatomical research led him also to the discovery that a part at least of this crystal-like body was nerve substance, a step in advance as compared with J. Müller's views. The latter physiologist had indeed observed that the nerve

really reached the posterior surface of the crystal-like body; nor has any anatomist since his time doubted the nerve character of the fibre behind it. The various form of this fibre (as before described) was not, however, known or clearly demonstrated until Gottsche first, and after him Leydig, described the peculiar swellings, ridges, and knot-like expansions of the nerve so unlike anything hitherto observed in nerve structures. Nor was it until after long-continued and laborious investigations that Leydig finally expressed his opinion that the whole apparatus was nothing more than a peculiar modification of terminal nerve fibre, and, in fact, the homologue of the rod or cone in which the fibres of the vertebrate retina end. These cones or rods of the vertebrate retina are exceedingly minute in the mammalian eye, but in the lower vertebrates (e.g., frog, fish, &c.) are much larger and coarser. In the insect eye they are not only of a greater size and much more easy to prepare and examine, but they are also enclosed in separate sheaths, and have additions (such as muscle fibrils and tracheal tubes) which render them at first sight very unlike the rods and cones of the vertebrate retina. Nevertheless they agree in being terminal extremities of the nerve fibre, as also in the peculiar transformation of nerve substance into a highly refractive and transparent matter. They are, therefore, as much "percipient elements" as are the rods and cones of a vertebrate retina; and they further agree in this, that they are placed just where the images formed by the corneal facets fall. In the first part of this article, we alluded to the fact that true optical images were formed by the corneal lenses, and that these images must necessarily be produced in the plane immediately behind the cornea where the crystal-like expansions of the terminal nerves are situated. There is, therefore, no optical necessity for a second formation of images, but it is none the less certain that in this crystalline nerve end a series of refractions must occur. In the vertebrate eye, images formed by the lens are transferred to the back of the globe, where the rod or cone ends of the retinal fibres are disposed so as to meet the surface on which the image is formed. This disposition is similar in both kinds of eye; the *ends* of the fibres are opposed to the picture, and the direction of the bacilli or rods is radial to the centre of the eye. But, in the one case, the images and the "percipient bacilli" are in the front of the eye—that is, vision is directly forwards—whilst in the other case the images and percipient bacilli are at the back of the eye, and each nerve fibre entering the eyeball from behind turns back upon the inner surface and looks towards the bottom of the eye; that is, vision is directed backwards. This inversion of sight is a special characteristic of the vertebrate eye.

And further, notwithstanding the differences of size, form, and position of the bacilli of the insect eye as compared with those of the vertebrate eye, an important agreement in respect to the physical character and molecular arrangement of their substance has been recently noticed by Schultze. The substance of the vertebrate retinal rod has been discovered to be composed of matter having different refractive power, which is so disposed that the length of the rod is made up of discs piled on each other. Under favourable circumstances, a faint striation of cross lines may be seen when the retinal rod is examined under the microscope and is in perfectly fresh condition. In the club-shaped swelling, and indeed throughout the length of the nerve fibre of the insect compound eye, a similar striation is readily seen (the insect rod being larger and thicker); but on no other nerve structure, as far as is yet known, does this peculiarity exist. The cross markings are solely due to the different refractive power of the alternate elements or discs by the superposition of which the rod is formed. The fact is especially important, as it promises a further clue to the explanation of the physical conditions of vision. Hitherto the optical image has always been considered the final point to which physical investigation could conduct us. But in the newly discovered properties and composition of the retinal rod (which has been of late years universally acknowledged to be the *percipient element*), a step further towards the physical analysis of visual phenomena seems to be gained; namely, the mode in which physical impressions of light may be transferred to the percipient element. Between the physical impression of light and the actual sensation or sense of sight there will always probably remain a chasm which no physiological enquiry can ever bridge over. But it is possible to conceive a differential process in the transmission of light impressions which may serve to render our ideas of what is perceived and *how* perceived more intelligible. And perhaps the perception of colour, to an explanation of which these newly discovered facts apparently point, may receive a better elucidation. If such hopes be fulfilled, it may fairly be inferred from the close analogy of the bacillar structure of the insect compound eye with the retinal rods of the vertebrate eye, that a similar perception of colour as well as form may be predicated of the insect as well as of man himself.

We should be paying an ill compliment to the readers of the Popular Science Review by offering any apology for the lengthy and minute details of the structure and function of the insect eye which we have here attempted. The day is passed when popular science was supposed to be acceptable only when it was superficial and unscientific!

EXPLANATION OF FIGURES.

Plate XXXVII.

Fig. 1. Section through the compound eye of Libellula: *a*, cornea, continuous with chitin skin of insect; *b*, layer of "bacilli" between cornea and optic ganglion—radially disposed so as to converge from periphery to centre; *c*, pigment investing inner ends of the bacilli which are continuous with nerve fibres of optic ganglion; *d*, optic ganglion.

" 2. Surface view of cornea of Libellula: showing facets (six-sided). The division into facets is marked by a deeper-coloured shade, which corresponds to a more pigmented and denser portion of corneal substance.

" 3. Cornea with subjacent stratum of "bacilli" of Libellula: *a*, the exterior corneal surface shows lenticular facets; *b*, vertical lines indicating the division of corneal substance (through its thickness) into constituent portions corresponding in width to that of the facets on its surface; *c*, pigment investing outer ends of "bacilli" (*d*) which are enclosed in sheaths (see fig. 4) extending from inner surface of cornea to surface of optic ganglion; *e*, pigment investing inner ends of bacilli.

" 4. Two bacilli, composed of sheaths of membrane enclosing nerve substance, the outer swelling of which corresponds to the "crystalline body" of authors. To examine the bacillar structure under the microscope, solution of caustic potash must be used to dissolve the pigment.

" 5. Section across the bacilli (horizontal section), showing the circular outline of the sheaths, which are coated with pigment. The clear lumen within is occupied by nerve substance of bacilli.

" 6. Vertical section of cornea and bacillar stratum of Libellula: *a*, outside corneal surface (curved facets); *b*, inner corneal surface forming a plane curve—vertical lines through the thickness of cornea between the "corneules"—horizontal lines are more faintly perceptible, showing a disposition of the substance in zones or laminæ; *c*, on the right side of fig. 6, the membranous sheaths are shown with their contents—nerve and crystalline body; *d*, on the left side the sheaths are shown empty. The outer and inner ends of three sheaths (the middle portion having been cut away in the preparation) are seen attached to inner corneal surface and outer surface of optic ganglion; *e e*, optic ganglion—a tracheal tube runs concentric with its outer border; *f*, fibres of optic nerve.

" 7. Simple eye of Salticus æneus. Vertical section showing *a*, cornea and lens formed by thickening of laminæ of corneal substance; *b*, zone of pigment round the lens; *c*, choroid pigment; *d*, the "corpus vitrium" of J. Müller (the bacilli of Leydig continuous with); *e*, nerve fibrils; *f*, retinal cells.

Plate XXXVIII

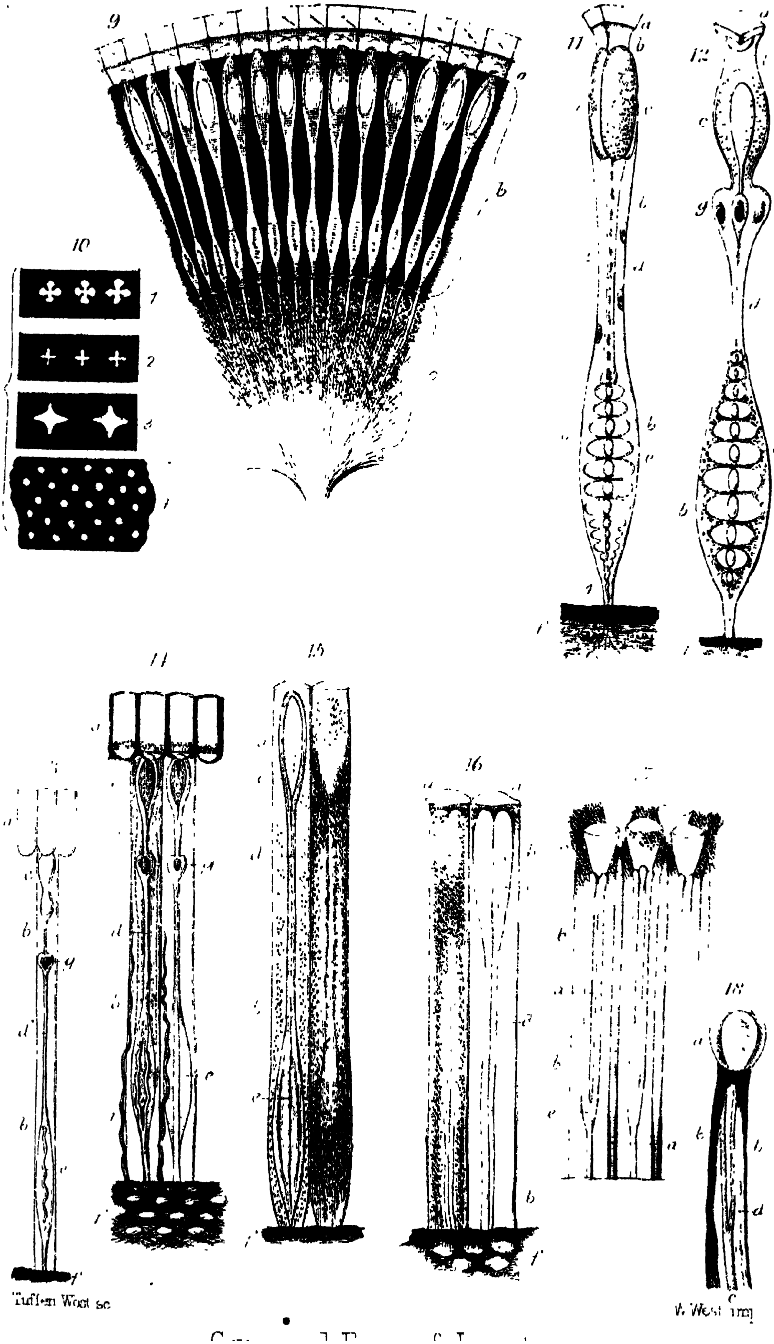

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Fig. 8. Simple eye of Vespa crabra. Vertical section showing cornea and lens as above (*a*, *b*); *c*, bacillar stratum; *d*, choroid pigment; *e*, retinal cells.

PLATE XXXVIII.

„ 9. Section of portion of eye of cray-fish—Astacus fluviatilis: *a*, cornea; *b*, bacillar stratum; *c*, optic ganglion.

„ 10. Sections across a bacillum at different points in its length (see 1, 2, 3, 4, fig. 11), showing its four-lobed shape where it swells to form the "crystalline body;" next in order, its cruciform shape in the middle; its four-ribbed club-like expansion below; and lastly, its simple round form where it pierces the pigment lying on the optic ganglion.

„ 11. Shows in detail all the parts lying under a corneule in direct (radial) line to the optic ganglion. Astacus fluviatilis: *a*, corneal facet; *b*, sheath—on the inner wall are seen three nuclei adhering to it; *c*, four-lobed enlargement ("crystalline body") continuous below with (*d*) the quadrangular nerve rod; *e*, inner four-ribbed club-like swelling; *f*, optic ganglion.

„ 12. Shows the same details in eye of Herbstia condyliata; *a*, *b*, *c*, *d*, *e*, *f*, as in former fig.; *g*, four-lobed (nucleated) expansion of substance situate between the crystalline body (*c*) and club-shaped swelling below (*e*).

„ 13. The same details in eye of Dynastes, letters as before.

„ 14. Ditto ditto ditto Procrustes coriaceus; *a*, *b*, *c*, *d*, *e*, *f*, *g*, as before; *j*, fine tracheæ lying inside the sheath. The red lines denote muscle fibrils within the sheath.

„ 15. From eye of Mantis religiosa, letters as before.

„ 16. Ditto Schizodactyla monstrosa, letters as before.

„ 17. Ditto Syrphus; *a*, trachial tubes; *b*, *c*, *d*, *e*, as before.

„ 18. Ditto Acridium cœrulescens; *a*, four-lobed crystalline body; *b*, sheath—with pigment deposit; *c*, nerve; *d*, muscle fibril.

TRUE AND FALSE FLINT WEAPONS.

By N. WHITLEY, C.E.

Hon. Secretary to the Royal Institution of Cornwall.

IF we endeavour to trace backwards the history of mankind in Western Europe, we have to pass from the vividly written history of our own times, through the dimness which envelopes the fragmentary records of the earliest historians, to the darkness of improbable traditions and monstrous fables. But where written history fades away into fable, there archæology steps forward with the materials for the construction of the history of an age of which no written records remain. The works of prehistoric man have been exhumed from peat bogs, sepulchral mounds, lake margins, caves, and gravel-beds; and a flood of light has been thrown on the history of the past from these materials, more authentic than that which is written—more faithfully preserved than most of the manuscripts of antiquity. There is a fascination in the study of these monumental records which has lured us on to push our enquiries so far back into the past, that this additional light there also gradually fades away, until we reach the darkness which shrouds the study of high antiquity; when doubts arise which have never been dispelled, and probably mistakes made which have yet to be rectified.

Adopting for convenience the division of the stone period proposed by Sir John Lubbock, that of *Palæolithic* for the first stone age, embracing the chipped but unground implements from the Drift; and *Neolithic* for the second or more modern stone age, characterised by beautiful weapons and implements of polished stone; we find the domestic history of the early races of man exhibited with much clearness throughout the whole of the *Neolithic* period. The barbed arrow-heads, the finely-chipped daggers, the ground axes and chisels, call for our admiration of the skill of the workman, considering the imperfection of the tools he had, equally with the Sheffield cutlery of to-day. In the remains of the lake dwellings of Switzerland where polished stone axes are abundant, we trace the outlines of

huts built for shelter and defence; of the people who inhabited them, we find the tools they used, the cloth they wove, the corn they crushed and baked, and the ornaments they wore; and from the whole we can draw a faithful picture of their labours and pursuits. But when we take one step further back into the *Palæolithic* age, we find a complete change in the nature and weight of the evidence, that which before was clear and undoubted becomes dark and unsatisfactory; all trace of man is lost except by his implements, and these formed of one kind of stone—flint—only, of a type wholly different from that of the following age, never ground or polished or showing any indications of use, and "so irregular in form as to cause the unpractised eye to doubt whether they afford unmistakable evidence of design." *

These stone implements pass by such insensible gradations into other forms of fractured flint obviously the result of natural causes, that their advocates find it difficult to determine whether they are artificial or natural.

In the Salisbury Museum there is a collection in which an attempt is made to distinguish between the true and the false implements.

In the Museum of Practical Geology in Jermyn Street, there are a large number of rough stone "implements" side by side with naturally fractured flints of approximate form, the object being to show that the simpler forms referred to fortuitous fracture may have suggested the type of the "undoubtedly artificial implements." But the attempt to refer some to one class and some to the other confessedly breaks down on an inspection of the labels. Thus in series D, six specimens in succession are described as—

42. "Seems entirely natural."
43. "Seems also entirely natural—perhaps used.
44. "Apparently being dressed into form."
44*a*. "Natural or partly dressed."
44*b*. "Natural or partly dressed."
45. "Appears dressed."

On inspecting the series, I found No. 10 to approach nearest to the St. Acheul type, but even this flint is described as "Natural, but perhaps chipped at the edge."

When a careful inspection of the "implements" by a professed geologist and antiquary leads to so much difficulty and doubt, how are we to distinguish between the false and the true, between the work of nature and the work of man? Where are we to draw the boundary line between geological

* "Antiquity of Man," p. 379.

facts and archæological records? We are thus entering on a subject which is ripe for enquiry; and when we consider that the presence of man in Europe in the *Palæolithic* age rests on the authenticity of the flint implements, and on these alone, the subject is invested with an importance which demands a most searching investigation.

The evidence must be derived from the implements themselves—from the position in which they are found—and the undoubted works of man with which they may be associated.

On each of these topics the implements of the *Neolithic* age speak for themselves, and in language so clear and decisive that it cannot be misunderstood; they are of a form and size adapted to the use for which they were designed, are mostly polished and ground to a cutting edge, and some bear decisive evidence of having been used. They are found associated with the undoubted works of man, and cannot be inspected without producing the conviction of their human origin.

The evidence of *use*, if not the most conclusive, is the most impressive. I found a celt of the ordinary form on the surface of the soil near Abbeville, the point of which had been rubbed into a peculiar shape by the friction of the purpose for which it had been used. On the top of the chalk cliffs, two miles west of Beachy Head, two days' search produced four flint celts: the marks of designs on the whole were unmistakable, but one of superior workmanship had been broken by a blow from a finer pointed implement, the sharply formed dent on its surface, the bruised substance of the flint below, and the conchoidal fracture which severed it in two, attest the great force of the blow. I could not resist the conviction that it had probably been broken in battle; and I found two other *broken* celts near the same spot.

It is important in its bearing on this enquiry to observe that the boundary line between the early and later ages of stone is sharply defined and easily recognised, and Sir John Lubbock says: "It is not going too far to say that there is not a single well-authenticated instance of a 'celt' being found in the drift, or an implement of the drift type being discovered either in a tumulus or associated with remains of the later stone age." * There is, however, at least one apparent exception. The flint flakes, the most perfect of which are assumed to be arrow-heads and flake knives, range through all parts of the stone ages both in archæological time and geological position; they are found in the gravel-beds of the Somme with the remains of the mammoth; in the caves of the Dordogne with the horns of the reindeer; and in burial mounds with instruments of bronze and iron. The flakes appear to increase in

* "Prehistoric Times," p. 280.

number as they near us in time, 30,000 being found in one Belgian cave associated with human bones. But through all this long period there is no progressive improvement in their make, no recognisable attempt at superior finishing. They are of the same type, fracture, and rudeness of form throughout. Are these flint flakes implements made by man? Are they the refuse chips of ancient manufactories? Or have they been formed by natural causes, and some of them selected and adapted for use by man?

A first glance at a pile of indiscriminately collected flakes does not impress the mind with the conviction of their human manufacture, and it is with a feeling somewhat akin to surprise to hear their paternity so strongly asserted. Sir Charles Lyell, quoting Mr. Evans, observes "that there is a uniformity of shape, a correctness of outline, and a sharpness about the cutting edges and points which cannot be due to anything but design." * And Sir John Lubbock says: "A flint flake is to the antiquary as sure a trace of man as the footprint in the sand was to Robinson Crusoe." †

From an extensive examination of the flakes themselves, and of their geological position, from Cornwall to Norfolk, in Belgium, and in France, I have obtained sufficient evidence to compel me to adopt the contrary opinion; and it will lead to a clearer understanding of the subject if this evidence be put as a direct argument to prove their geological position and origin.

Their Geographical Distribution has an evident Relation to Geological Structure.

The north of Ireland has a substratum of chalk which appears to occupy but a very small area on a geological map; it encircles Antrim with a wavy band like a green ribbon. But it is, in fact, the outcrop of a wide-spread formation, which has been disrupted by ancient volcanic action, and now lies buried under enormous masses of basalt. The chalk had suffered great denudation before the volcanic matter was ejected, and a stratum of flints, left on its surface, has since been covered by molten lava, converting the chalk into hard white limestone, and baking and fracturing the flints. The ruin of the chalk has been swept southward, and the valleys and lowlands have been loaded with drift, conspicuous among which are shattered flints and an abundance of flakes. At Toome, on Lough Neagh, they are found in large quantities on the bar when the water of the lake is low; and they are scattered along the course of the river Bann downwards to the sea. The drift has been swept over

* "Antiquity of Man," p. 117. † "Prehistoric Times," p. 67.

the islets on Strangford Lough, and there also the flakes abound; and they may be found for miles among débris at the foot of the white limestone hills.

The chipped and barbed flint arrow-heads, so beautifully perfect in workmanship and symmetrical in form, are equally distributed throughout Ireland, but the ordinary flakes cleave so closely to their paternal home in the chalk, that the 700 flakes in the museum of the Royal Irish Academy were nearly all obtained from the counties of Derry, Antrim, and Down.*

The chalk of the south of England has neither been broken up by the intrusion of igneous rocks, nor suffered denudation equal to that of Ireland; but on Salisbury Plain, at Andover, Whitchurch, Rochester, and Eastbourne, I have collected an abundance of flakes. And where the drift of Norfolk has ploughed up the surface of the chalk, I have found them in greater quantities, especially around Thetford, where they are thin and sharp.

In no other part of Western Europe has the chalk suffered so much from denudation as in Denmark, it forms the basement beds of Jutland and the islands, and it has been rasped down by glacial action, and buried under thick beds of northern drift. If prehistoric man had lived as a savage hunter near this cold period, we might have expected to find his flake implements few and far between; Schoolcraft estimates that it requires on an average seventy-eight square miles for the support of one hunter; and the Indians of the Hudson's Bay Company require ten square miles to each individual. But, on the contrary, the flakes and chips are most abundant in Denmark. Sir John Lubbock says: "To give an idea of the numbers in which they occur, I may mention that Professor Steenstrup and I gathered in about an hour at Froëlund, near Korsör, 141 flakes, 84 weights, 5 axes, 1 scraper, and about 150 flint chips." . . . "Some spots are often so thickly strewn with white flints that they may often be distinguished by their colour, when at a considerable distance." †

In Northern France there is a large development of chalk, forming the geological rim of the Paris basin; I surveyed it from north to south during the past summer. From the watershed which passes from near Boulogne to St. Pol and Bapaume, and thence further eastward, I found that angular flint gravel had been washed down the slopes on the northward over Belgium, and through the valleys of the Somme and the Oise on the south. Much of the high land was coated with loess, but where the winter torrents had exposed a section the shattered

* Catalogue of Antiquities in the Museum of the Royal Irish Academy.

† "Prehistoric Times," p. 81.

flints were abundantly disclosed. At Spiennes, three miles south-east from Mons, where 400 "flint implements" were discovered, I found the flakes large, thin, and broad, in a stratum six inches thick and two feet under the surface of the soil; I traced them for half a mile along a sloping cliff formed in a gorge of the river, and the soil around teemed with similar forms. In the valley of the Somme, at St. Acheul and Menchecourt, the flakes were delicately thin, long, and sharp at the edges. Crossing the Paris basin to its southern rim, I drove up the valley of the Claise to Grand Pressigny. The hill-sides were often cut into steep cliffs, and débris of the chalk, mixed with much granitic gravel from the central highlands, formed a soil full of split flints, flakes, "axes," or "ploughshares," or "cores." Through the courtesy of Dr. Leveillé, I was shown a vast number of "implements" ranged around three rooms in his house, and the walks of his garden were bordered with innumerable "axes." My first search in a ploughed field produced more flakes and axes than I could carry; but "*the manufactory*" at La Douchetterie lay full three miles to the south, where similar flints are so numerous that "M. Brouillet collected in his cart, in less than an hour, such a number that they weighed above 500 kilogrammes" * (about half a ton).

Southward on the Oolite hills no flakes have been discovered; but further south, in the departments of the Charente-Inférieure and Dordogne, the chalk becomes largely developed and the flakes again become most abundant.

In Sicily and in Syria, on the desolate shores of the Dead Sea, in Arabia Petræa, and on the Algerian Sahara, the flakes are widely scattered, and in all these places found in intimate relationship to cretaceous strata.

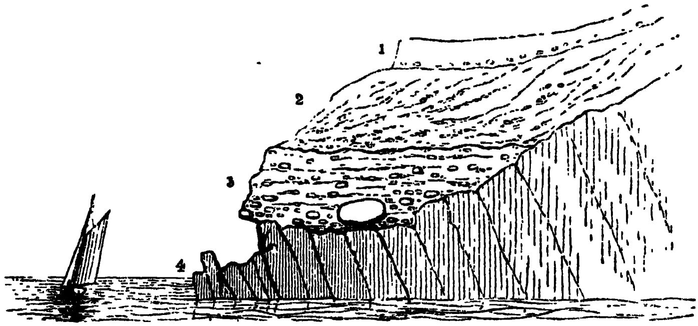
But the flakes are often discovered in great numbers far away from the chalk and on the oldest sedimentary rocks. In such cases it is commonly asserted that they must have been carried there by man. Around Barnstaple, by works of drainage and cuttings for roads, I have traced them over an area twenty miles long and ten miles wide, and found them at intervals from Hartland point, along the north coast of Cornwall, to the Land's End, and even on the granite islets of Scilly; but here the evidence of their drifted origin can be read at a glance.

The sketch on the following page shows a section of these beds on the north side of Bideford Bay, and the position of the flakes at the base of the soil.

This so-called raised beach is composed of drifted materials, much of which is foreign to the rocks on which it rests. At the base of the drift is a large boulder of granite, with others of por-

* "Memoirs of Anthropological Society," vol. ii. p. 323.

phyry, trap of many varieties, basalt with the angles partly rounded, and chalk flints. Similar deposits form links on both sides of St. George's Channel, which enable us to trace back their origin to the granite, basalt, and chalk of the north-east of



1. Soil with flint flakes at base. 2. Head of local rubble.
3. "Raised beach." 4. Devonian rocks upturned.

Ireland. Professor Jukes says: "Chalk flints and pieces of hard Antrim chalk are found in the drift in the counties of Dublin and Wicklow, and along the whole eastern and southern coast of Ireland, at least as far as Ballycotton Bay, on the coast of Cork." * And Mr. Trimmer shows that Antrim chalk has been drifted southward to Caernarvonshire.†

The Flakes in Section are often found in true Geological Position.

On much of the unreclaimed land of Cornwall, at the base of the soil, there is a layer of crushed quartz rock, provincially termed "spar;" and when the land is enclosed for cultivation the first operation is to trench the soil deep enough to take out the "cold spar." The crushed quartz occupies precisely the same place at the base of the soil as the shattered flints and flakes shown in the upper stratum of the above section. I have found this to hold good over a wide extent of country, for my workmen in forming drains and roads find the flakes about eighteen inches below the surface of the soil. At Berling Gap, near Eastbourne, a portion of the chalk cliff was expected to fall, and the farmer removed the soil, some forty feet wide and half a mile long, from the top of the cliff further inland; the newly exposed surface is coated with shattered flints and flakes, some being very perfect flake knives. Near Thetford the

* "Manual of Geology," p. 675.
† "Royal Agricultural Journal," vol. vii. p. 482.

chalk is covered with a barren sand forming an extensive rabbit warren; there are many delicate flakes on the sand, but they are most plentiful where the rabbits have brought them to the surface by burrowing below. But the most satisfactory illustration of the geological origin and position of the flakes is that which I obtained at Spiennes. The valley, half a mile above the village, contracts to a narrow gorge and suddenly turns at a right angle to the open basin above; at this point the river, when in flood, has had its full force thrown on the slope of the left bank, where it has washed the flakes out of the subsoil and brought them to the surface. In the narrower part of the valley down stream on the steep slope of the hill-side the stratum of flakes is exposed in section, and those from the excavated portion are scattered over the surface of the garden below.

This section at the top of a garden at the south end of Spiennes village shows the following beds in descending order:—

1. Surface soil of rearranged Loess 2 feet.
2. Stratum of flint flakes 6 inches thick.
3. Loess with fractured pieces of angular flint 4 feet.
4. Pure Loess about 20 feet resting on chalk.

The layer of flakes may be traced a considerable distance along the hill-side. They are in form from three to six inches long, broad, irregular in outline, and thin; showing on one side a perfect bulb of percussion and a clean conchoidal fracture, and on the other numerous facets; that they had a geological and not an archæological origin appears from the regular manner in which they are interstratified with the other beds. They bear no indications of design, nor any evidence of use.

Where the soil has been thinned by rain, as on the brows of hills, or has been disturbed and removed by river action, there the flakes are brought to the surface and have a white coating; while those preserved from atmospheric influence in the subsoil have a clean, fresh-looking fracture, with very sharp edges.

Thus in Devonshire and in Sussex, in Belgium and at Pressigny le Grand in France; the flakes are most generally found at the base of the soil, indicating a geological rather than human origin.

But the flakes speak for themselves. Those which I have collected form, with the accompanying shattered flints, a large pile on my office floor in addition to the hampers-full which I have stowed away.

They show a gradation in *size* from $\frac{1}{8}$ of an inch to 8 inches in length. A gradation in *form* from the roughest fracture to the most perfect flake. The good and the bad are all mingled in indiscriminate confusion; but the most degraded

savage would not cast away his well-formed implements with the refuse chips. They show no additional workmanship beyond the ordinary fracture of the flint, and bear no evidence of use. In North Devon the flakes are found over an explored area of 200 square miles, and surely it cannot be said that a few scattered savages required a manufactory for weapons two hundred times as large as that requisite for the British navy at the magnificent dockyard of Keyham.

The flakes are further found on precipitous cliffs overhanging the Atlantic, where a savage could scarce find foothold to make them; and on solitary islets at Scilly where man never could have subsisted in the hunter state.

That some of the flakes have been selected and used by man both archæology and history testify.

From the South Downs, in addition to three polished celts, I obtained a large flake which was ground to a cutting edge in the same manner as the celts. And the ceremony which placed flint knives in the tomb with Joshua, has been many times since repeated at the barrow interments on the British hills.

THE PLANET MARS IN FEBRUARY 1869.

By RICHARD A. PROCTOR, B.A., F.R.A.S.
Author of "Saturn and its System," "Half-hours with the Telescope," &c. &c.

AT the last opposition of Mars, I had the opportunity of discussing in these pages some of the phenomena presented by this interesting planet. In my paper on the subject,* I dealt with certain points which, as it appeared to me, should have found a place in our popular treatises of astronomy. The effects of the eccentricity of the planet's orbit, the nature and epochs of the seasonal changes which take place upon his surface, these and other such points seemed to require a closer attention than they had received in the ordinary books of astronomy. For instance, I believe that the diagram of the orbits of the earth and Mars which accompanied that article was the first in which the true relations of these orbits have been exhibited on an exact scale. Yet the effect of the relations thus presented is one of the most striking in the economy of the solar system. It had been discussed, in general terms, again and again, yet no one had been at the pains to illustrate it—in other words, to present it in that form which alone has any real significance to nine out of ten of those who read treatises on popular science.

Having thus, in that paper, examined what I hold to be the fundamental relations of the planet Mars, I now feel freer to discuss other questions—considerations connected with the physical habitudes of the planet, its fitness to be the abode of living creatures, and other such points. I would, however, refer those who wish to know how the planet and the earth will be situated at the approaching opposition, to the paper here referred to. The line marked 1869 in the plate of diagrams accompanying that article indicates the direction in which the two planets are situated as respects the sun, on February 13, the day of oppo-

* Popular Science Review, No. 22, for January 1867.

sition.* It will be seen that the planet is nearly as far away from the earth as it possibly can be at such a time; but notwithstanding this peculiarity, there are circumstances which will render the approaching opposition fully as interesting to astronomers as those which occur when the planet is near perihelion.

In the first place, Mars will have a high northerly declination, whereas, when in opposition near perihelion, he is far to the south of the equator. Accordingly, he will rise fully thirty degrees higher above the horizon, and will be seen under proportionately more favourable atmospheric conditions.

But, secondly, it has happened that astronomers have paid more attention to the planet during those oppositions which have occurred when it has been near perihelion; and the result has been that the parts of the planet which will be most favourably seen during the approaching opposition have not been scanned with a sufficiently close scrutiny, and much remains to be done by those who wish to aid in delineating the features of the planet. For there is a considerable portion of the surface of Mars which can scarcely be seen at all, save when he is presented towards the earth as he will be during the approaching opposition and one or two following ones. A reference to the paper already mentioned will suffice to show that the southern pole of the planet is turned away from the earth when Mars is in perihelion; and although this pole becomes visible when the planet is still far from aphelion, yet it is only prominently brought forward when Mars is almost exactly in aphelion. Nor is this all. The presentation of the same pole towards the sun has to be considered. We shall presently have occasion to discuss the climatic relations of the planet, and we shall see reason for believing that, in many important respects, they resemble those of the earth. During the winter season of either hemisphere, clouds appear to be much more densely aggregated in the Martial atmosphere than during the summer season. Hence it results that we obtain a far better view of the hemisphere which is enjoying the progress of the Martial summer than we do of the other. And, as the hemisphere which is bowed down towards the earth, at the time of opposition, is also bowed down towards the sun, we are not only enabled to obtain a more direct view of that hemisphere when so bowed down, but it is also the hemisphere which is freest from clouds, and its real surface, therefore, is more distinctly visible than that of the other hemisphere.

* There is a slight error in the position of this line, which should have been 3° farther advanced in longitude. A similar error appears in Fig. 36 of Lockyer's "Lessons in Astronomy," which presents the same relations.

It will be well in the first place to examine the exact relations which Mars will exhibit as respects the presentation of his polar axis towards the earth during the approaching opposition. A general impression can be obtained of his presentation by considering the indications of my chart of the orbits of the four interior planets. But as some persons find it difficult to grasp with clearness and distinctness the results which follow when two globes like Mars and the earth have a certain relative position—that is, to gather how one of them would appear to an observer situated on the other—I have thought it well to calculate the exact presentation of Mars with relation to the declination circles and parallels of the celestial sphere, because the knowledge of this point enables the observer to at once interpret the meaning of his observations without reference to the hour of observation or to the position of the planet with respect to the horizon.

The following table presents all that is necessary to be known respecting the presentation of the planet, at bi-monthly intervals. Here *d* is the apparent diameter of the planet; *p* is the apparent angle at which the northern extremity of the planet's polar axis is inclined to a declination-circle (towards the east in the present case); and *l* is the angle at which the line of sight from the earth to the planet is inclined to the plane of the planet's equator (this line being on the northern side of the equator in the present instance).

	p	*d*	*l*
	″	° ′	° ′
December 16, 1868 .	11·2	12 29 E.	24 33 N.
December 31, ,, .	13·0	13 50 ,,	24 26 ,,
January 14, 1869 .	14·6	13 36 ,,	23 50 ,,
January 29, ,, .	15·8	11 28 ,,	22 50 ,,
February 13, ,, .	16·4	7 39 ,,	21 39 ,,
February 28, ,, .	15·8	3 52 ,,	20 24 ,,
March 15, ,, .	14·4	1 18 ,,	20 7 ,,
March 30, ,, .	12·8	0 37 ,,	20 32 ,,
April 14, ,, .	11·2	1 9 ,,	21 36 ,,

Since the apparent path of the planet across the field of view of the telescope indicates the position of the declination-parallel, there can be no difficulty in interpreting these results, and thus assigning the spots seen in the planet to their proper position on the globe of Mars.

Figs. 1, 2, and 3 (Pl. XXXIX.) indicate the presentation of the planet on December 16, February 13 (opposition), and April 24, respectively, as seen in an inverting telescope. They will assist in interpreting the table given above. It will be noticed

that the darkened crescent which indicates the gibbosity of the planet does not, either in fig. 1 or in fig. 3, correspond with the position of the planet's polar axis. Since, in fig. 1, the outline of the dark hemisphere clearly passes nearer to the planet's pole than the outline of the hemisphere visible to us, we are to infer that the polar axis of the planet is less bowed towards the sun than it is towards ourselves at the period to which this figure corresponds. On the contrary, at the period corresponding to fig. 3, the planet is less bowed towards the earth than towards the sun.

Since the last opposition of Mars a good deal has been added to our knowledge of the planet. I will begin with less important, but not, I think, uninteresting considerations.

It may be remembered that in dealing in these pages with the rotation-period of Mars, I spoke of the values assigned to this element by Mädler and Kaiser—the former giving 24 h. 37 m. 23·8 s. and the latter 24 h. 37 m. 22·6 s. But, some time after my paper was written, I had occasion to examine a large number of pictures of the planet for the purpose of combining the information they afforded, and so forming a chart of Mars. This work had already been done by Sir W. Herschel, then by Messrs. Beer and Mädler, and more recently by Professor Phillips; but it seemed to me that Mr. Dawes' admirable drawings of the planet promised to afford a chart of greater completeness than any of these, and, as the views which he had taken extended over upwards of twelve years, it was necessary, in order that they might be fairly compared *inter se*, and the identity of the various features of the planet fully made out, that the rotation-period of Mars should be determined with great accuracy. The discrepancy between the determinations obtained by Mädler and Kaiser, and the uncertainty I was in respecting the relative accuracy of these two astronomers, led me to test their estimates. I found that, for intervals of several years, either value corresponded very closely with observed appearances. In fact, it will be seen at once that a difference of a second in a Martial day would correspond to a difference of less than 365 seconds, or six minutes, in a terrestrial year.

But when longer periods were taken, Kaiser's value quickly showed a marked superiority, and I was led, as I had anticipated (Kaiser's being the latest estimate), to find a very close agreement between this value and the observed appearance of the planet at intervals of fifteen, twenty, or even thirty years. This was, in fact, all I wanted, since, as I have said, Dawes' drawings covered only a period of twelve or thirteen years. But having gone thus far, I thought it would be well to enquire how far Kaiser's period availed to account for the rotation of Mars during longer intervals, especially as there were several pictures

Plate XXXIX

Fig 1.

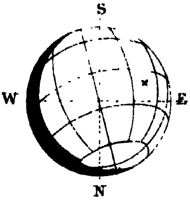


Fig. 2

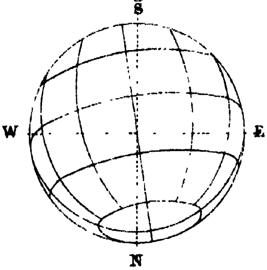


Fig 3.

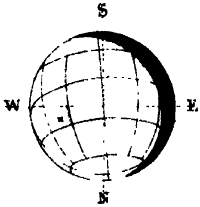


Fig. 4. *Chart of Mars on Mercator's Projection.*

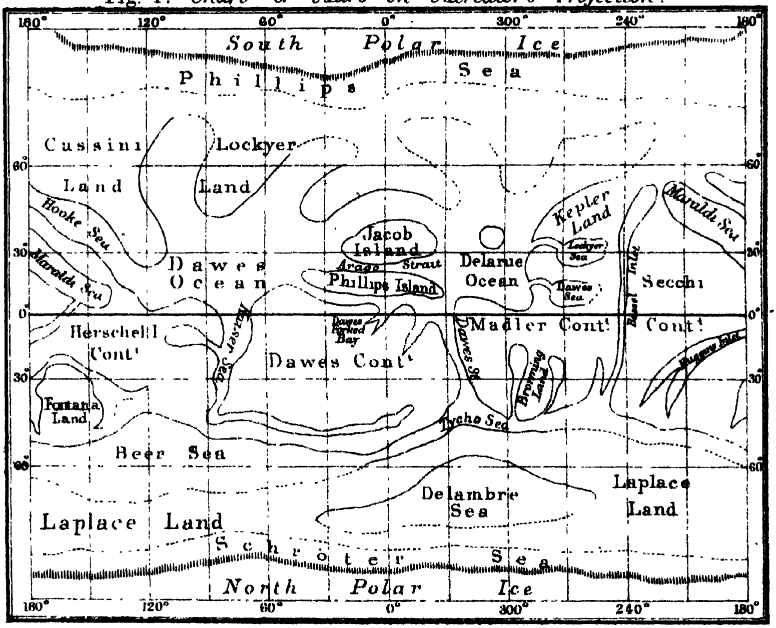
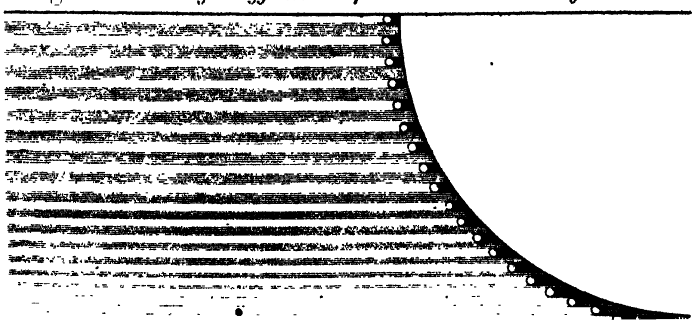


Fig 5. *Illustrating suggested explanation of Mars' bright limb.*



by Sir W. Herschel in the years 1775–1783, one or two by Maraldi early in the eighteenth century, and two by Hooke in the year 1666, which seemed sufficiently distinct to be available for the purpose I had in view. I found that Kaiser's value did not bring these several views into accordance. For example, in a period of seventy-nine years, Kaiser's value brought out a discrepancy corresponding to an hour's rotation of the planet; and when the full period of 198 years which separated the earliest of Hooke's from the latest of Dawes' drawings was examined, a discrepancy resulted which there was no mistaking. In other words, when the aspect of Mars was calculated backwards from the date of one of Mr. Dawes' latest drawings, with Kaiser's value of the rotation-period, a result was deduced which differed wholly from the view given by Hooke in 1666. This result was confirmed later, when I was able to make use of a drawing of Mars taken by Mr. Browning with one of his eight-inch reflectors in February 1867. Here a period of 201 years was made use of, and it need hardly be said that, when once one has obtained a value so near to the true rotation-period as to be certain of the exact number of rotations which have taken place in so long a period, the error affecting the value of a single rotation is very small. In the following table I present the results of calculations applied to three long intervals, viz. from March 12, 1666, 12 h. 20 m. (astronomical time and new style), in each case, to

(i) April 24, 1856, 10h. 50m.
(ii) November 26, 1864, 11h. 46m.
and (iii) February 23, 1867, 6h. 45m.;

the drawings corresponding to (i) and (ii) having been made by Mr. Dawes, the one corresponding to (iii) by Mr. Browning.

Int.	Interval in Seconds	Cor. for Geo. Long.	Cor. for Phase	Corrected Interval in Seconds	Number of Rotations	Resulting Rotation Period
(i)	5999524200	0°	−12°	5999521246	67682	88642·737
(ii)	6270650760	−248	0	6270589696	70740	88642·734
(iii)	6341394300	−273	+ 3	6341326590	71538	88642·734

It results that Mars' rotation period lies between 24 h. 37 m. 22·73 s. and 24 h. 37m. 22·74 s. Within these limits, this result may, I think, be depended upon; because an error of one-hundredth part of a second in a single rotation would mount up to 715 seconds, or nearly a quarter of an hour in the long interval numbered (iii); and the appearance of Mars changes very perceptibly in a quarter of an hour.

But I would call attention here to the absurdity of assigning

to Venus, as is sometimes done, a rotation-period carried to the second decimal place of seconds. Thus Di Vico's period, 23 h. 21 m. 23·93 s., is often spoken of as if it might be trusted to the last figure, and as a veritable triumph of astronomical accuracy of observation. But, as a matter of fact, this determination, founded as it is on a comparison of Di Vico's observations in 1840–2 with those of Bianchini in 1726–7 (a period of 116 years), could not be depended upon to the last figure, even if it were certain that the exact number of rotations taking place in the interval is known. But this cannot be the case, since observations of Venus have not been made often enough in the interval to enable us to carry back our estimate over gradually-increasing periods, as we can in the case of Mars; and, without this precaution, it is quite impossible to be certain that no rotation is missed in the long interval. Even in a short period of two years, Sir W. Herschel dropped a rotation in the case of Mars; and Venus is so much more difficult an object, and the spots upon her are so little recognisable (especially where telescopes of different power have been made use of by the observers whose views are to be compared), that there is much more likelihood of a similar mistake being made in her case.

My former paper on Mars was accompanied by a plate presenting eight ideal views of the planet as it was to be seen during the opposition then approaching. These views were formed from the study of eight drawings of Mars by Mr. Dawes in 1864–5. I believe the attempt was the first that had ever been made to forecast the physical aspect of a planet in this way. But I was not wholly satisfied with the charting of the planet, and as I had it in view at that time to draw up a monograph on Mars, I ventured to apply to Mr. Dawes for tracings of a few drawings taken when the planet was presented in other ways to us. With the kindness for which he was so remarkable, and which endeared him so much to all who became acquainted with him, he immediately sent me ten or twelve drawings and afterwards searched through his note-books for others. In all, if I remember rightly, he sent me twenty-one drawings, taken in 1852 (a most valuable series in this year), in 1856, in 1860, and in 1862.

The task of charting Mars from these drawings was not so easy a one as might at first sight have been supposed. Mr. Dawes had taken them at various hours, and there were no ready means of determining the position of the planet's axis in each case. A tentative process had to be gone through—for I was anxious that the charting of Mars should be independent of all previous efforts in that direction.

Having calculated the presentation of Mars for the date of each drawing, I drew on tracing-paper the meridians and

parallels properly presented (on the scale—in each case—of the corresponding drawing by Mr. Dawes). Then beginning with the most promising view I placed the tracing-paper over the picture of the planet, giving that position to the polar axis which corresponded most closely with the assigned position of the polar snow-caps. Then on a projection of the meridians and parallels of a globe on the equidistant projection, I drew in the lands and seas of Mars as they appeared under the meridian-lines on the tracing-paper. I next repeated the process for other drawings in which the same features were presented.

At first there was little accordance between the results thus pencilled on my chart-projection. This was caused by erroneous selections of the axial line of Mars, which—it must be remembered—does not correspond with the position of the polar snow-caps. But gradually I began to get over this difficulty and the views began to show a much closer agreement. Still there were slight discrepancies, and these, when reduced as much as possible by shifting the assumed position of the axis, I was obliged to ascribe to such slight errors as could not fail to appear in drawings so full of detail and taken under such circumstances of difficulty as were Mr. Dawes' pictures. Therefore, having drawn in all the outlines deducible from pictures nearly approaching each other in phase, I took a *mean outline* through the others to be as nearly as possible correct.

It must be understood that the amount of Mars' surface covered by one such series of processes would be very much less than a full hemisphere, since—firstly, the part of Mars near the limb was not drawn in so distinctly in Dawes' pictures as the rest, and secondly, a small mis-drawing in an orthographic presentation of a planet becomes much more important as we leave the centre of the disc, so that I did not consider myself justified in using those delineations which were not near the centre. It must also be remembered that as the drawings were not taken at periods separated by regular intervals of Martial time, it was very necessary to apply to each a correction calculated according to the true value of Mars' rotation-period. Thus it will be understood that before the whole of the surface of Mars had been charted a considerable amount of labour had been given to the subject. Those who have never tried work of this sort would hardly be able to conceive how perplexing it often becomes. But one circumstance was very pleasing. I found that the more carefully I worked at the chart, the more thoroughly the true value of Mr. Dawes' drawings came out. I had had little conception, when I began the work, either of the acuteness of his vision or of the accuracy of his powers of delineation. The tracings he sent me were partially covered with faintly marked streaks which I had at first supposed to be

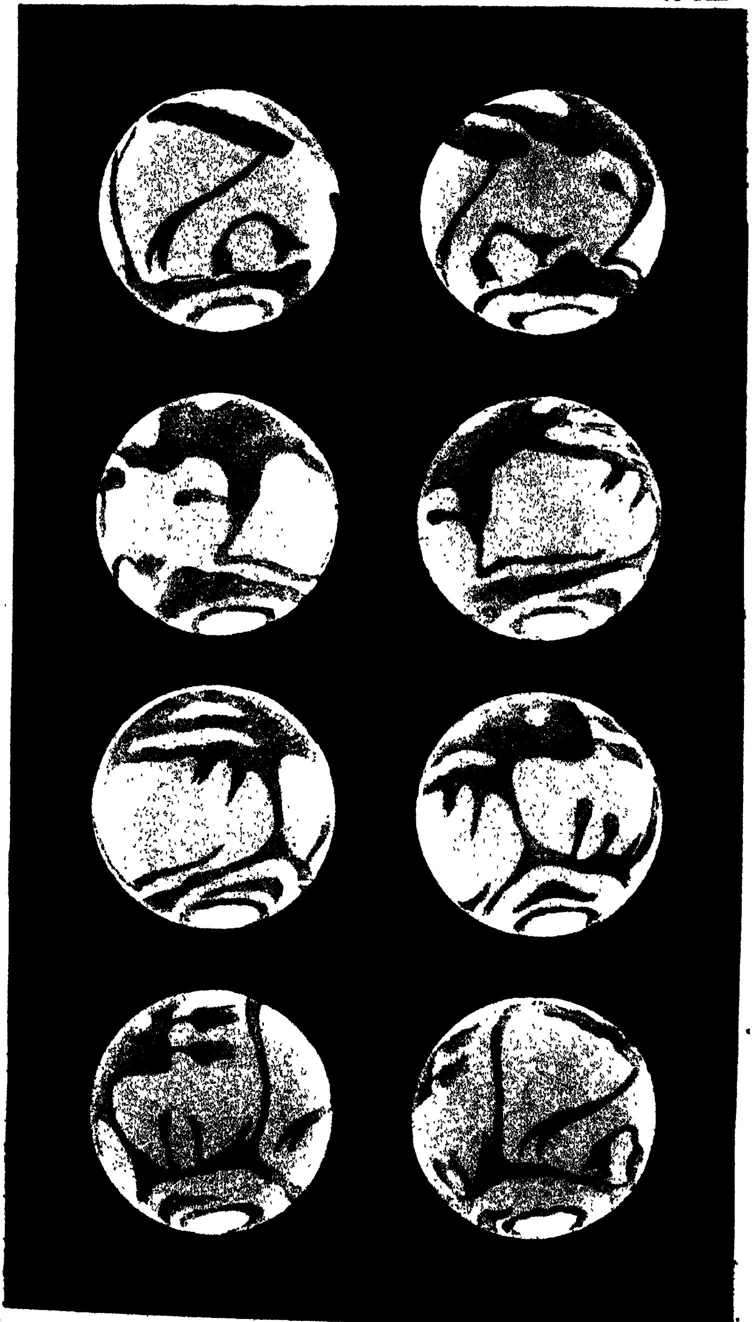
merely random touches thrown in to indicate the general appearance of that part of Mars to which they belonged. But I soon found that every one of these streaks was to be taken as the indication of a Martial marking which Mr. Dawes had actually seen. The strange variations of figure which a spot on a globe undergoes when the globe is looked at in various directions, had prevented me at first from recognising the identity of several large markings. Mr. Dawes himself was not aware in some cases, that a spot which was presented with one figure in one drawing was in reality the same as one which appeared with a totally different figure in another drawing. But when due account was taken of the effects of foreshortening, the almost perfect correspondence between the different views, indicated at once the accuracy of Mr. Dawes' drawing, and the permanence of the spots which mark the globe of Mars.

The result was the construction of a chart of Mars containing a number of features which had not before appeared in works of the sort. In my "Half-hours with the Telescope," (Plate VI.) a small copy of the equidistant chart originally drawn by me is presented. Fig. 4 (Pl. XXXIX.) represents the same features on Mercator's projection. If a series of tracings be taken from figs. 1, 2, and 3, and the features represented in fig. 4 be drawn in, according to the meridians and parallels of the respective figures, the aspect of Mars as he will appear during the present quarter will be deduced. Plate XL. represents eight views of Mars in opposition; so that if Mars be observed on any night, say from February 3 to February 23, he will be found (if the observer's telescope be sufficiently powerful) to present an appearance resembling one or other of the views in this plate.

A feature of the planet Mars which has recently attracted some attention has been incidentally noticed above. I refer to the whiteness of the disc near the limb. This phenomenon is worthy of a careful examination; and I believe that the true explanation has not yet been put forward.

In the first place it is to be remarked that this phenomenon is *real* and not merely apparent. The edge of Jupiter's disc seems to be brighter than the central part, but is in reality darker. I believe ninety-nine observers out of a hundred would be deceived regarding this feature of Jupiter, if they trusted to the unaided eye. Why it should be so, is not perhaps very easy to say. Perhaps the contrast between the dark background of the sky and the illuminated limb of the planet tends to give to the latter a brightness which does not belong to it. Be this as it may, a series of observations which Mr. Browning has lately made on Jupiter, with the express object of determining this question, has resulted in placing the greater darkness of the planet's limb, as compared with the central part of the

Plate XL.



W. West lith.r

disc, beyond a doubt. He used darkening glasses perfectly graduated from end to end, and by this means was enabled to obtain the most accurate estimate of the relative brilliancy of various parts of the disc.

But the greater darkness of Jupiter's disc near the limb is what was theoretically to have been expected. An opaque globular body directly illuminated by a distant luminous orb should appear brightest in the centre of its disc; because the real illumination diminishes as the angle at which the light rays meet the surface diminishes, and the apparent brilliancy at any point of an object is always equal to the real illumination at the point.

In the case of Mars then, the apparent illumination of different parts of the disc, varies in a manner which is directly the reverse of what was theoretically to be expected. Therefore, it behoves us to determine with so much the greater accuracy whether the eye may not be deceived in this as in the former case. I believe the experiment applied by Mr. Browning to Jupiter's disc, has never been applied to that of Mars. But, fortunately, a series of photometrical experiments by Dr. Zöllner, although not directed to the question we are considering, but to the determination of the total amount of light received from Mars at different epochs, yet affords a satisfactory reply to our doubts. For it will be easily understood that when a globe is not illuminated strictly according to the usual law—but, from some reason unknown, presents an anomalous variation of brilliancy—the total amount of light received from it at different times will not correspond with the estimate deduced according to the usual law. For example: the moon's light at full does not bear to the moon's light at the quarter the proportion which would exist if the moon were a perfectly smooth globe, and therefore illuminated strictly according to the law mentioned above (in dealing with Jupiter), and by assuming—what is practically the case—that the illumination of the hemisphere of Mars turned towards the sun varies according to some law depending merely on the distance from the central point of that hemisphere, it follows that, by noting the amount of light received from Mars at different times—and especially by comparing the amount received from him in quadrature, with that received when he is in opposition—it becomes possible to deduce the law according to which different parts of his disc are illuminated. For although when Mars is in quadrature his gibbosity is not very remarkable (see figs. 1 and 3), yet the true centre of the illuminated hemisphere is removed a considerable distance from the centre of the disc,* and the total illumination is therefore affected in a remarkable manner by the planet's gibbosity.

* Its place is marked by a small cross in figs. 1 and 3.

Accordingly, Zöllner was able to estimate the anomalous illumination of various parts of Mars' disc. He had already done this in the case of the moon, and had come to the conclusion that the anomalies in the lunar illumination (mean) are due to the existence of irregularities over the moon's surface, and he estimated the mean angle of inclination of the slopes of the lunar mountains to be somewhat over fifty degrees. Assuming that the same explanation held in the case of the anomalies of Martial illumination, he found that the surface of Mars must be covered with mountains having a slope of about seventy-six degrees.

But this view is utterly untenable. We accept Zöllner's explanation in the case of the moon; in fact we may almost say that it is obviously the true one. We can conceive no other cause available to produce the effect considered, and further we see that all over the moon there are mountains having very steep sides. But in the case of Mars we cannot admit such an explanation because a large part of the surface of the planet appears to be covered with water, and because also, a slope of seventy degrees and upwards is outrageously steep. Mars ought to be covered all over with hills shaped like sugar-loaves to account for his anomalous illumination in the way suggested by Zöllner.

To us a far more natural way of explaining the difficulty seems to be the following. We have every reason for believing that clouds form over the surface of Mars as over that of the earth. Secchi, Dawes, Lockyer, and Browning, agree in describing effects which can scarcely be due to any other cause. And besides we shall presently see that there is good reason for feeling absolutely certain that the vapour of water exists in large quantities in the atmosphere of Mars. Now, it would not be a very bold speculation to argue from the observed anomalies in the illumination of Mars, that clouds prevail much more towards morning and evening (Martial) than in the middle of the day. If this were so, it would, of course, follow that the parts of Mars which as seen from the sun lie near the edge of the limb, would be much more brilliant than the rest. For they are the parts where it is morning or evening with the Martialists; therefore according to the assumption they are cloud-covered; but clouds reflect much more light than the solid or liquid surface of Mars; therefore these parts of the disc would seem proportionately more brilliant.

But we are not even required to make such an assumption as this. For if clouds were pretty uniformly distributed over the whole surface of Mars there would still result a greater brilliancy of the limb. Consider fig. 5 for example. Here a fourth part of the circumference of Mars is supposed to be illuminated by the sun on the left, and clouds are represented which are

arranged with perfect uniformity all round this quadrant. When the light falls between the clouds it is supposed to be returned after a considerable absorption, corresponding to the shaded spaces. When it falls on a cloud it is supposed to be returned after much less absorption—that is, to remain much more brilliant after reflection, corresponding to the unshaded spaces. And it is at once seen that near the limb all the light is (in this imaginary case) derived from reflection at the clouds, whereas, near the centre of the disc, the larger proportion is derived from reflection at the real surface of the planet.

There is nothing doubtful in the above explanation except the assumed existence of small clouds—invisible separately to the naked eye. But this assumption seems at once more natural, and to explain the difficulty better than the sugar-loaves of Zöllner.

It may be, however, that when the sun is near the horizon of Mars, heavy mists hang in the air, as happens commonly enough with us both in the morning and in the evening. This would account equally well for the observed peculiarity.

I should be glad to hear that any one armed with a telescope of adequate power had done something to test the climatic relations of Mars, and also the diurnal changes in the state of the Martial atmosphere. By noticing at what part of the disc the features appeared most distinct (allowance being made for real differences in the distinctness of the markings), something might readily be done in this way. The spectroscope also might be rendered very efficiently available in this inquiry. It has been already noticed by observers that the winter hemisphere is perceptibly less distinct on the whole than the summer hemisphere. For example, the features marked in the upper halves of the figures in Plate XL. may be expected to be less distinct than those on the lower. But then, as there are places on earth where the winter climate is drier than elsewhere, so it may be that parts of the winter hemisphere of Mars may be more distinct than others. In considering diurnal changes account must be taken of the gibbosity of Mars at the time of observation, because, as we have said, the centre of the disc of Mars may be far removed from the centre of the illuminated hemisphere.

Perhaps the most remarkable discovery yet made respecting the physical condition of Mars, is that contained in a communication addressed to the Royal Astronomical Society, by Mr. Huggins, early in the year 1867. From this paper I extract the following particulars.

On several occasions during the opposition of 1867, Mr. Huggins was able to make observations of the spectrum of the planet's light, or, to use his own accurate phraseology, "of the solar light reflected from the planet." During these observations he saw groups of lines in the blue and indigo parts of

the spectrum. But the faintness of this part of the spectrum did not permit him to determine whether these lines are the same as those which occur in the same part of the solar spectrum, or whether any of them are new lines due to absorption undergone by the light at reflection from the planet.

He also detected (as in former observations) several strong lines in the red part of the spectrum, and it is to these that the chief interest of his paper attaches. He saw Fraunhofer's C very distinctly, and another line about one-fourth of the way from C towards B. As the latter line has no counterpart in the solar spectrum it was clearly due to an absorptive effect produced by the planet's atmosphere. On February 14, Mr. Huggins was able to detect faint lines on both sides of Fraunhofer's D. These lines occupied positions in the spectrum apparently coincident with groups of lines which make their appearance in the solar spectrum when the sun is low down, so that its light has to traverse the denser strata of the atmosphere. It remained however to show that these lines were produced by the atmosphere of Mars and not by that of our own earth. This Mr. Huggins effected in the following manner:—The moon was, at the hour of observation, somewhat lower down than Mars, so that if the lines were due to the absorptive effects of our atmosphere, they should have been more distinctly marked in the spectrum of the lunar light than in that of the light from Mars. But when the spectroscope was directed to the moon these lines were not visible, thus conclusively proving that the lines were caused by the absorptive action of the Martial atmosphere. Mr. Huggins noticed in confirmation of this that the lines seemed more distinct in the light from the margin of the disc, but he was not quite certain on this point.

This observation proves the presence of aqueous vapour in the atmosphere of Mars, since the lines in question have been shown to be caused, in the case of our atmosphere, by the vapour of water.

From the spectroscopic analysis of the darker portions of the disc of Mars, Mr. Huggins was led to the conclusion that these parts are neutral or nearly so in colour.

He considers also that the ruddy colour of Mars is not due to the effects of the planet's atmosphere. Indeed, this seems almost obvious when we consider that the polar spots look perfectly white, or at least show not the slightest tinge of red, though, being situated upon the edge of the disc, they should exhibit the effects of the atmosphere's absorptive powers on the rays from the blue end of the spectrum, more strongly than the central parts of the disc, where the light has passed through a much smaller range of atmosphere. Clearly we may look upon the red colour of parts of Mars as due to the nature of the planet's soil.

ON THE MOLECULAR ORIGIN OF INFUSORIA.

By JOHN HUGHES BENNETT, M.D., F.R.S.E.,
Professor of the Institutes of Medicine in the University of Edinburgh, &c., &c.

PREVIOUS to the time of W. Harvey, life was considered to be an independent principle capable of being added to, or removed from, inert matter. Such was the opinion of the ancient philosophers as allegorically explained by the fable of Prometheus, who animated the marble statue by fire stolen from heaven. But our modern view of life is, not that it is independent of matter but a condition of matter; in other words, that material substances, found in the atmosphere and in plants and animals, influenced by certain forces, have peculiar properties communicated to them. These properties are contractility, sensibility, the power of growth in certain directions and mental acts—the existence and exercise of any one of which constitute life.

Harvey put forth the law *omne vivum ex ovo*; and since his day the belief has been general, that animals and plants are derived from eggs or seeds; that vitality is always transmitted, and never created; and that, where these fundamental principles cannot be recognised, the minuteness of the germs and their wide diffusion throughout nature, and more especially in the atmosphere, offer a sufficient explanation of what may appear mysterious. Nature, it was argued, must be uniform in her operations, and analogy warrants our supposing that the same law of generation, which applies to the higher animals and plants, is equally applicable to the lower.

In later times, Buffon imagined life, like matter, to be indestructible. According to him every living molecule had a life of its own, and the method by which it manifested its function depended on its association with other molecules. Thus, the body of an animal or a plant was the aggregation of a multitude of minute living beings arranged in a particular way. The death of the complex compound was simply a dissolution of one of these associations, and the organic molecules

thus set at liberty wandered about until they once more combined with a plant or animal—here with a monad, there with a quadruped. The *materia vitæ diffusa* of John Hunter was something similar.

In the present day physiologists, with the assistance of those powerful microscopes which opticians have placed in their hands, have traced the changes which ova and seeds undergo during their development in a vast number of animals and of plants. In this way it has been established that some forms of animal life may be propagated without generation by parents. Such interruption in descent Owen has called parthenogenesis, from παρθενεία, virginity. Thus, two winged insects will produce an animal without wings, from which ten or twelve generations of individuals may be derived without a fresh act of conception, until the last in the chain gives forth another winged insect, when the process is repeated—as in the case of the aphis. Lastly it has been shown that the very lowest forms both of vegetable and animal life cannot be traced back to spores or ova. The law of descent, therefore, from parents, *homogenesis*, which we recognise in the higher organisms, changes as we descend in the scale, first to *parthenogenesis*, where this direct descent is broken, and ultimately to *heterogenesis* in which it is lost. It is to the last of these processes attention is directed in the present article.

On making a cold or hot infusion of any vegetable or animal substance, covering the vessel with a piece of paper so as to exclude the dust, and then watching it every twelve hours, the first change visible to the eye is a slight opalescence, and the formation of a thin scum or pellicle that floats upon the surface. This appears at times, varying from a few hours to several days, according to the temperature of the atmosphere or the nature of the infusion. On examining the pellicle or film under high magnifying powers, it is seen to be composed of a mass of minute molecules, varying in size from the smallest visible point to that of one thirty-thousandth of an inch in diameter. These molecules are closely aggregated together, and must exist in incalculable numbers. They constitute the primordial mucous layer of Burdach,* and the proligerous pellicle of Pouchet.† The same pellicle, examined six hours later, shows the molecules to be somewhat enlarged, and these separated by the pressure of the upper glass are already seen here and there to be strongly adhering together in twos and fours, so as to form a little chain. Many twos, also, have apparently melted together so as to form a short staff or filament —*bacterium* (fig. 1, *b*). Twelve hours after this, it may be

* "Physiologie, par Jourdan," tome ii. p. 123.

† "Hétérogénie," p. 383.

seen that the grouping of the molecules in twos, threes, and fours has become more general, and that several of these form new groups of eight lengthways. Many of them have melted together to produce longer bacteria. At the edges of the mole-

FIG. 1.

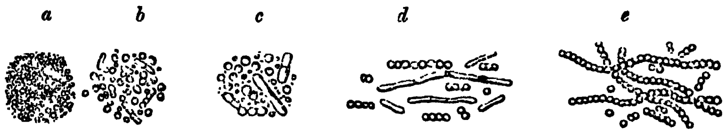


Fig. 1.—*a*, Molecular structure of the proligerous pellicle on its first appearance in a clear animal infusion. *b*, Molecular structure of the same, six hours afterwards. The molecules have been separated, and several are seen grouped together in twos and fours. Some of these have melted together so as to produce bacteria, which exhibit a trembling movement. *c*, The structure of the proligerous pellicle on the second day, separated. The molecules are coalescing in rows and melting together to form longer bacteria or vibrios, which move rapidly across the field of the microscope. As their development proceeds, they present the appearance seen in *d*, and in fig. 2. *e*, Long filaments composed of adhering molecules. 800 diameters linear.

cular mass, and in the fluid surrounding it, may now be seen a vibratile movement in the shorter bacteria and a serpentine movement in the longer ones, whereby they are propelled forwards in the fluid—*vibrio* (fig. 1, *c*, *d*). From the second or third to the fifth or seventh days, the vibrios are lengthened, evidently by apposition of groups of other molecules, to their ends. These melt together to form a filament, which may extend a third or half, and in a few cases entirely across the field of the microscope (fig. 2).

FIG. 2.

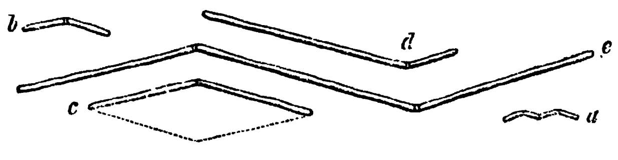


Fig. 2.—*a*, Vibrio with a serpentine movement. *b*, Vibrio with one flexure, evidently formed by the union of two bacteria. *c*, Elongated vibrio with one flexure, the area of the movement marked by a dotted line. *d*, An elongated vibrio, not moving; a bacterium evidently added at one extremity. *e*, An elongated vibrio with two flexures, moving rapidly across the field of the microscope. An observation of these vital structures evidently indicates aggregations of bacteria and vibriones of a certain length endways, the flexures occurring at the points of junction. 800 diameters linear.

The movements visible in the molecules and filaments vary according to the amount of development. At first those which float loose in the fluid exhibit gyrations which cannot be distinguished from Brunonian movements. When short bacteria are seen these exhibit peculiar vibrations—often turn round

on their own axis in various directions, and slowly change their place. They rarely dart rapidly through the fluid, or exhibit a serpentine motion. But when the vibrio is formed, the filament is pushed forward with greater or less velocity, at first presenting a wriggling, but, as it becomes longer, a more decided serpentine motion. A distinct flexure can be seen at certain points in the filaments, between the groups of molecular chains or filaments. Dumas says he has seen the molecules and bacteria uniting endways, a statement the correctness of which Pouchet doubts.* On two occasions, however, I was fortunate enough to see this occurrence as represented in the accompanying figures. (See figs. 3 and 4.) The reason this actual union

FIG. 3. FIG. 4.

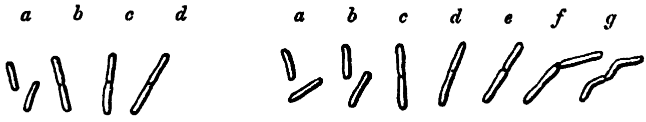


Fig. 3.—*a*, Position of two short bacteria. *b*, The lower bacterium was seen to sink down and unite itself to the upper, and then the two turned round in unison, as in *c* and *d*.

Fig. 4.—*a*, Position of two bacteria. *b*, Altered position of the same. *c*, The lower one adhering to the upper. *d*, The two turning together to *e*. *f*, Vital flexure at the middle; and *g*, four flexures, when I saw the vibrio so formed move forward out of the field of the microscope. 800 diameters linear.

has so seldom been seen is, 1st, That it only occurs at certain periods of development, and can only be followed by the eye, when the movements are slow; 2nd, That amidst such a multitude of minute moving bodies it requires a long time before two can be found exactly on one plane, and can be brought so accurately into focus that they can be watched for a sufficient time. Having, however, in the two instances described and figured, actually seen the coalescence, I can have no doubt whatever that such is the true method of elongation.

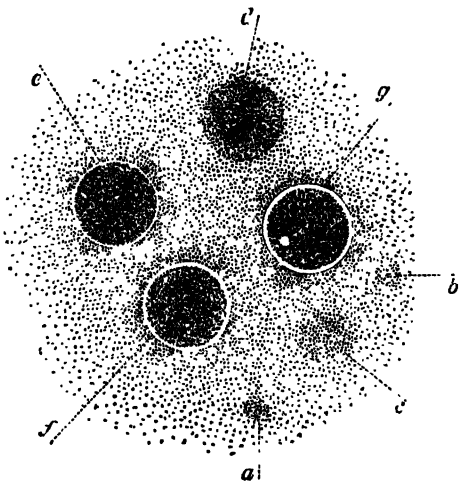
It may frequently be observed, on again examining the fluid in which these bodies have been moving actively, that they are all motionless, evidently dead. This occurs at various periods. They now rapidly disintegrate, and thus a second molecular mass or pellicle is produced. In this, rounded masses may be seen to form, which strongly refract light not unlike pus corpuscles, or the colourless corpuscles of the blood. These soon begin to move with a jerking motion dependent upon a vibratile cilium attached to one of their extremities—*Monas lens.* In a day or two other cilia are produced, the corpuscle enlarges, is nucleated, and swims through the fluid evenly. Varied forms

* "Nouvelles Expériences," p. 115.

may now occur in the molecular mass, dependent on the temperature, season of the year, exposure to sun-light, and nature of the infusion, all having independent movements. They have been denominated *Amœbæ*, *Paramecia*, *Vorticellæ*, *Kolpoda*, *Keronæ*, *Glaucoma*, *Trachelius*, etc., etc.*

Pouchet describes the *Paramecium* as originating in the proligerous pellicle, formed by the breaking down of the primary bacteria and vibriones. It is the secondary histolytic mass of molecules which arrange themselves as seen in fig. 5.

FIG. 5.



Formation of Ova in the proligerous Membrane.

a, Coalescence of molecules. *b*, The same more advanced. *c*, Still larger mass. *d*, The same assuming a rounded form. *e*, A membrane formed externally. *f*, Complete differentiation of the now perfect ovum from the surrounding molecular mass. *g*, A nucleus apparent.—*Pouchet*. 250 diameters.

It would occupy too much time to follow the development of all the forms that may arise. They always originate long after the primary vibrios are produced, in the secondary, tertiary, or even later molecular masses, resulting from the disintegration of previous forms.

It frequently happens that soon after some of these higher infusoria are seen, that the pellicle falls to the bottom of the fluid, where it constitutes a dense precipitate, and slowly breaks down; then another scum forms on the surface, and molecules, bacteria, and vibrios are again produced.

The varied forms produced are spoken of by Ehrenberg and other naturalists as being different species;† but I think it will

* See Ehrenberg's "Infusoria." † Ibid.

be found that the laws, not only of molecular but of alternate generation and parthenogenesis, prevail among them, and one frequently passes into another. Their production is largely dependent on temperature, state of the atmosphere, light—especially the sun's rays—and other physical conditions.

At other times, it happens that the molecular mass, instead of being transformed into animalcules, gives origin to minute fungi. In this case the molecules form small masses, which soon melt together to constitute a globular body, from which a process juts out on one side. These are *Torulæ*, which give off buds which are soon transformed into jointed tubes of various diameters, terminating in rows of sporules (*Penicillium*), or capsules containing numerous globular seeds (*Aspergillus*). Occasionally filaments are formed from the direct melting together of molecules arranged longways (*Leptothrix*). (See fig. 1, *e*.)

Here also I think various forms regarded as distinct plants pass into one another—especially torulæ, which are only embryonic forms of higher fungi. In all these cases no kind of animalcule or fungus is ever seen to originate from pre-existing cells or larger bodies, but always from molecules.

That we should sometimes have animalcules, and at others fungi, is a well-known fact, the exact causes or conditions producing which are not yet explained. The Panspermatists, of course, are of opinion that the germs in the atmosphere are of many kinds, and that as they fall into various infusions they produce different results, in the same manner that varieties in ova or seeds develop themselves in peculiar localities or special soils. This assumption, however, seems to me opposed by the following experiment:—

If an infusion be placed in a deep glass vessel, which again stands in the centre of a shallow vessel containing the same infusion, and the whole covered with a large bell glass, it will be found in eight days that on the surface of the former are numerous ciliated animalcules, while on that of the latter only bacteria and vibrios exist. The experiment may be reversed, for if the shallow vessel be filled to the brim, and the deep vessel has only its bottom covered, then the ciliated microzoa will appear in the former, and the non-ciliated in the latter.*

It is difficult to explain how germs falling from the air on the same infusion, under identically similar conditions, with the exception that the fluid is in vessels of different forms, can vary the results. Whereas the fact that the higher infusoria are formed secondarily out of the disintegrated mass of the simpler

* Pouchet's "Nouvelles Expériences," &c., pp. 135, 243-245. Paris, 1864.

ones, which can only take place where that mass is considerable and floating on the surface of deep fluids, directly confirms the molecular theory of growth, and offers an illustration of how successive disintegrations give origin to different formations.*

That the infusoria originate and are developed in the molecular pellicle which floats on the surface of putrefying or fermenting liquids, has been admitted by all who have carefully watched that pellicle with the microscope, more especially by Kutzing,† Pineau,‡ Nicolet,§ Pouchet,‖ Jolly and Musset,¶ Schaaffhausen,** and Mantegazza.†† The question therefore is, are the molecules that constitute that pellicle derived from the air or the fluid—are they precipitated from above, or do they float to the surface from below, like the globules of the milk which produce cream?

Now, it was in consequence of having professed to demonstrate what had escaped all previous observers—viz. the germs in the air—that M. Pasteur has made his name so famous. He tells us‡‡ that he did so by causing a current of air to pass through a glass tube in which a pledget of gun-cotton had been placed. This was then dissolved in ether, and the sediment allowed to collect in a watch-glass. This sediment, after being repeatedly washed, and allowed to remain in distilled water for twenty-four hours at a time, is allowed to dry. A portion of the dried matter is then put upon a slide moistened with a weak solution of potash, and, being covered with another glass, is examined with the microscope. The results he has figured; and, very properly, he has given the scale of magnifying power under which they were drawn (fig. 10), and which, by careful measurement, I have ascertained to be 180 times linear. These are his drawings, carefully copied.

He says figs. 6 and 7 represent organised corpuscles from dust collected in twenty-four hours, from November 16 to 17, 1859. The manner in which the e drawings, giving the volume and outline of the bodies, were made, is as follows: "After the dust has been prepared in the manner described, I took a por-

* See "On the Molecular Theory of Organisation," by the Author. "Proceedings of Royal Society of Edinburgh," 1861.

† See Schaaffhausen, "Comptes-Rendus," tome liv. p. 1046.

‡ "Annales des Sciences Naturelles," 3me série, tome iii. p. 182. This observer thinks he saw disintegrated fibres of meat and of other substances formed directly into vibriones; in this he was incorrect.

§ "Arcana Naturæ," tome i. p. 2.

‖ "Hétérogénie," p. 353. "Nouvelles Expériences," p. 111.

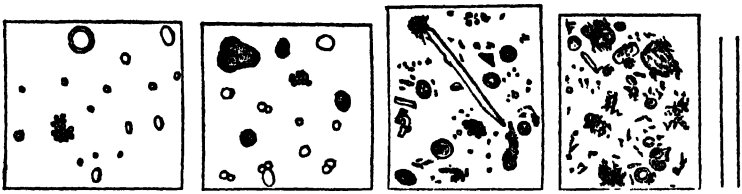
¶ "Comptes-Rendus," tome l. p. 934. ** Ibid. tome liv. p. 1046.

†† "Institut Lombard," 1852, tome iii.

‡‡ "Annales des Sciences Naturelles," 4me série, tome xvi. p. 25.

tion of it from the watch-glass, and diluted it with a solution of potash, consisting of 5 parts of potash in 100 of water. As soon as I perceived a globule evidently organised under the microscope, I drew it. This is how fig. 4 was drawn." * This description leaves it uncertain whether an exact copy was taken of any portion of the field of the microscope, and, therefore, whether the figure represents the exact number of corpuscles present, and their relation to each other. It only gives their

FIG. 6. FIG. 7. FIG. 8. FIG. 9. FIG. 10.



Exact copies of the figures given by M. Pasteur of the dust he collected on gun-cotton, magnified 180 diameters. These should be compared with fig. 1, magnified 800 diameters, showing what is seen to take place when infusoria are forming. Fig. 10, scale of one-hundredth of a millimètre.

form. But, assuming that the same kind of demonstration was made in each case, we have the relative numbers of these bodies taken from the gun-cotton in fig. 6. Fig. 7 is another demonstration of the same after the addition of an aqueous solution of iodine. Fig. 8 represents the organised corpuscles associated with amorphous particles obtained on June 25 and 26, 1860; fig. 9, the dust of an intense fog in the month of February 1861. In all these demonstrations he admits the organised corpuscles are comparatively scarce, because, he observes (p. 31), it is frequently necessary to change the field in order to see one of them, whilst at other times several could be seen together.

M. Pasteur thinks that these drawings indicate the number of organised corpuscles that may be arrested in a small mass of cotton through which 1,500 litres of air, in one of the less-frequented streets of Paris, have passed in twenty-four hours, about three or four yards from the ground. These he estimates at several millions in a litre (p. 29).

Now, it must be remembered that M. Pasteur is a chemist, and it will be admitted by every histologist that no method could be more unsatisfactory for determining either the nature or the number of the corpuscles than the one he adopted. The solution of the cotton in ether, the frequent soakings in water, the desiccation, and then the addition of a solution of potash, must completely alter the character of any living corpuscles in

* "Annales des Sciences Naturelles," 4me série, tome xvi. p. 25.

the atmosphere. Then the forms he assumes to be organic, are not necessarily so. They are exceedingly frequent among mineral substances, and siliceous rounded forms are common, which of course resist sulphuric acid.

Numerous investigations have been made, both before and since M. Pasteur wrote, to determine the nature of dust floating in the atmosphere—of that dust, for example, which a ray of sunlight reveals to us, when admitted into a chamber. It consists, for the most part, of different kinds of starch corpuscles; the débris of clothing, especially filaments of cotton, silk, and wool; the results of different kinds of combustion, whether of coal or of wood; various mineral bodies, globular or ovoid, amorphous or crystalline; and minute fragments of insects and vegetables; very rarely small seeds and microscopic animalcules.

These constituents vary to such an extent in different localities, as to enable the observer, in some cases, to determine whence the dust was collected. Starch corpuscles abound in the neighbourhood of flour-mills and bakeries; fragments of clothing where there have been crowded assemblies of persons, cotton and wool being predominant if the persons belong to the poorer classes, and silk if the upper classes have been present; the products of combustion predominate in smoky localities; mineral particles on the roads and highways; seeds, fragments of vegetables and insects, in market places, gardens, &c., &c. But although these constituents of the air vary in different places, infusoria, produced in all of them, are identically the same.*

This has been tested in various ways. The dust has been ransacked to discover organic germs—collected and carefully examined with the microscope, near the soil, and on the summits of the highest buildings, not only in frequented, but in desert places; in crowded assemblies, as well as in empty Gothic cathedrals and ancient vaults—in the ancient palace of Karnack, on the banks of the Nile; in the tomb of Rhamses II. at the extremity of the Desert; as well as in the central chambers of the great pyramid of Ghizeh. The chief element of the dust collected in these places has been found to be starch corpuscles.† Large quantities of air have been drawn through tubes by aspirators, and collected on cotton, in distilled water, or projected on glass. The feathery snow, which, falling through the atmosphere, may be well supposed to collect its contents, has been melted, and the precipitate carefully collected. The emanations of marshy places, such as those of the Maremma in

* Pouchet's "Nouvelles Expériences," p. 73, *et seq.*
† Pouchet's "Hétérogénie," p. 446.

Tuscany, have been specially investigated.* The larynges and mucous pulmonary surfaces of numerous animals have been explored, even to the inmost bone cavities of birds. On the summit of Mont Blanc, amidst eternal snow; on the glaciers of the Jura and of the Pyrenees, and in the deep crevasse;† on the burning plains of Egypt, and in the markéts of Constantinople, the dust of the atmosphere has been microscopically examined, and in all with a like negative result as to the existence of germs. Nowhere could they be seen, nor if a few, in the opinion of some, were visible, could they in any way account for the multitude of minute infusoria, which, in all these localities, not only readily spring up in putrid fluids, but in every instance are identically the same.‡

Indeed, on examining the drawings of M. Pasteur (see figs. 6 to 9), let us suppose that the few bodies he has figured are truly sporules, as he believes them to be, which have preserved

FIG. 11.

1. 2. 3. 4. 5. 6.

Stages in the Development of Vibriones. 800 diameters linear.

their form—after the action of ether, several soakings of twenty-four hours each in water, the desiccation, and subsequent mixture with a weak solution of potash. How, it may be asked, could these bodies produce the incalculable millions of minute molecules in the smallest fragment of the pellicle we can transfer to our microscopes, in which, as we have seen, the infusoria originate? It has been supposed that, on falling from the air, they undergo rapid division, and spread over the surface with the greatest rapidity; but no one has ever seen this remarkable phenomenon, and the slightest consideration must show that such an assumption is completely adverse to what can be readily demonstrated on the surface of every infusion. Thus, there can be no doubt that the minutest molecules are formed first, and the bacteria, vibrios, and filaments, last. Supposing that the primary molecules, figured No. 1, in Fig. 11, enlarge to a certain point, No. 2, and then divide, how is it possible to explain the formation of elongated filaments at all? Surely the idea of their rapid multiplication by division is opposed to that of their power of elongating into bacteria and vibrios, whether by aggregation

* L. Gigot's "Recherches expérimentales sur la Nature des Émanations marécageuses." Paris, 1859. "Recherches sur l'Air des Maremmes de la Toscane," par M. E. Bechi. "Comptes-Rendus," tome lii. p. 852.

† "Comptes-Rendus," tome lvii. p. 558.

‡ "Nouvelles Expériences," p. 75.

or growth from their extremities. It may frequently be seen that No. 3 is composed of molecules of exactly the same size as No. 2, which are floating loose—a fact in favour of their coalescence rather than of their division, as then they would be reduced to half the size. It is more probable that although the smaller molecules may increase by imbibition of fluids, they have yet a constant tendency to aggregate together and melt into one another. No. 3 is not a proof of No. 2 dividing, but of two molecules coalescing; and when they unite, they form No. 4. Two or more of these uniting, form Nos. 5 and 6. When a similar process to this goes on in mineral bodies, as shown by Mr. Rainey,* it cannot suggest division, but union; and this for the obvious reason, that the former would lead to disintegration, whereas, it can be seen in one case as in the other, that development is the result. In short, in the same manner as a tube is formed by a coalescence of cells, so is this minute vibratile vibrio formed by the coalescence of molecules. It may be argued, however, that each molecule elongates itself—that is, No. 2 is converted into No. 4; this into Nos. 5 and 6; and that No. 3 are sporules or ova, caused by the disintegration of No. 6. But this view is opposed by the fact that Nos. 1, 2, and 3 are seen before Nos. 4, 5, and 6 are produced. Of this all have satisfied themselves who have examined animal and vegetable infusions; and the conclusion, therefore, cannot be resisted, that the vibrios are derived from the molecules, and not the molecules from the vibrios.

But it may also be supposed, that while some have the property of dividing, others are capable of elongating or aggregating; but this view is not only opposed to observation, but is at variance with all that we know of embryonic development in plants and animals. When a plant consists of a single structural element, such as a cell or a tube, it will, I think, be admitted that growth in the sense of increased bulk, and growth in the sense of multiplication of parts by division, do not proceed at the same moment of time. Every plant and animal follows, in this respect, the same law. Nutrition is carried on up to a certain point of maturity, and then, and not till then, does generation, or the separation of parts to form new creatures, take place. When plants and animals are complex in their structure, one organ or segment may be growing, while another is disintegrating; but in individual organs there is a period for growth and reparation, and a period for division or separation. Hence, it seems to me, I am correct in thinking that if the primary molecules on the surface of an infusion possess the property of dividing, they cannot also, at the same moment, possess the

* "On the Mode of Formation of Shells," &c., p. 12. 8vo. London 1855.

property of elongating and forming filaments. The one function is subversive of the other. While, then, a cell or a vibrio may possess the property of growth and division, these two functions must be exercised at different periods of time—so that, in reference to the early stage of formation, if the molecules divide, bacteria, vibrios, and filaments could not be formed. A mass of vibrionic molecules is not a compound organism; it is a mere aggregation of similar simple elements. Each of these in passing through certain phases of development may be arrested, or reach maturity at various periods, so that we frequently see different forms present at one time; but that the same forms and the same stages of growth should exhibit directly opposite functions, is surely not in accordance with physiological knowledge.

The conclusion we must arrive at therefore is, that the molecules seen on the surface of infusions out of which animalcules and fungi are produced, are not derived from the air.

Neither can they be supposed to pre-exist in the fluid, as then they would be readily seen, which they never are at the commencement. On this point nothing can be clearer than the microscopical evidence, so that it results from the facts and arguments which have been stated, that the more simple infusoria do not originate from cells or minute germs at all, whether in the atmosphere or in the fluid. This is the almost universal conviction of histologists who have carefully investigated the matter.

Again, it is almost universally considered that the heat of boiling water or cold at zero will destroy all kinds of animal and vegetable life. Indeed, to imagine that the minute molecules or vibrios of which we have been speaking, or small ova and sporules consisting of oleo-albuminous matter without any envelope, would remain in boiling water for hours and retain their vitality, must be regarded as a violent assumption. Three or four minutes' boiling of a hen's egg not only kills it, but converts its whole substance into a hard mass. There is no seed known, which, when taken out of its indurated shell or case, is capable of germinating after being boiled for a short time.* Yet nothing is more certain than that long ebullition of various infusions has wholly failed to prevent the formation in them of animal and vegetable growths.

Pouchet and others have frequently performed the following experiment: An open flask was plunged into and filled with a

* See some conclusive experiments recently performed on this subject by Meunier. "Comptes-Rendus," tome lxii. p. 992. See also Pouchet's "Experiments on the Seeds of Medicago from Brazil." "Comptes-Rendus," tome lxii. p. 941.

decoction of barley which had been boiling for six hours. A stopper was introduced into it below the liquid, and on taking it out the whole neck of the flask was immediately plunged into melting sealing-wax, and hermetically closed. In six days some yeast was observed in it, at a temperature of 18° cent. The following day the temperature was raised suddenly to 27°, when the flask burst, and then it was seen by the naked eye, and by the microscope, that it contained a notable quantity of yeast.* Now, yeast is a plant, which was thus proved to have grown in an infusion that had long been boiling, and from which all atmospheric air had been expelled.

As, therefore, neither calcined air, sulphuric acid, liquor potassæ, gun-cotton, or a boiling temperature have failed to prevent the production of infusoria, or destroy the supposed germs in the air or infusion, I determined, in 1863, to try the effects of all these destructive agents, with the exception of the first, at once, and with the greatest possible care. The results of numerous experiments carried on in this manner and varied in many ways demonstrate that when nothing but air, exposed to and filtered through agents most destructive to animal and vegetable life, is brought into contact with organic liquids, infusoria are still produced.

It is now admitted by M. Pasteur that the boiling temperature, that is, 100° centigrade, does not prevent the growth of the supposed germs in the atmosphere; but instead of considering this fact hostile to his theory, he concludes from it that the germs have the power of resisting that amount of heat, and of being most tenacious of life; but he says 130° centigrade always destroys their vitality. M. Pouchet, however, has shown that the air, and the organic matter when placed in boiling water, will germinate after they have been exposed to a heat of even 150°, and he says it may be raised to 200° centigrade, and yet animalcules and fungi will develop themselves.†

In the same manner, air and infusions exposed to intense cold still produce animalcules, but, according to Pasteur, not so readily. Twenty flasks containing boiled infusions, and from which the air was expelled, were opened by him with excessive precaution on the Mer de Glace at Montanvert on the Jura. Notwithstanding the purity and extreme coldness of the air infusoria appeared in five of his flasks.

As an illustration of the manner in which the controversy on this subject has been carried on in the Imperial Academy of Sciences in Paris, I may give a short account of that portion of it referring to the Glacier experiments. MM. Pouchet, Jolly, and Musset opened eight similar flasks used by M. Pasteur at

* "Hétérogénie," p. 629.

† "Comptes-Rendus," tome l. p. 1015.

Montanvert, on the Glacier of the Maladetta, in the Spanish Pyrenees, 9,000 feet above the sea, and 3,000 feet higher than that of Montanvert, using all the precautions required by M. Pasteur. In addition, before cutting off the ends of their hermetically sealed tubes with a file, previously heated by a lamp, they held the flasks above their heads. Notwithstanding, infusoria appeared in all the infusions a few days afterwards.*

To this communication, presented to the Academy, Sept. 21, 1863, M. Pasteur replies, Nov. 2,† saying that he is rejoiced that his learned adversaries have gone to such an altitude to repeat his experiments; but observes that they did not take the necessary precautions. They only had eight flasks, whereas he had twenty; they shook their flasks before opening them, which he took care not to do; and they had the imprudence to use a file instead of a pair of pincers with long branches, heated in the flame of a lamp. He says that the thumb and fingers holding the file were too near the opening into the flask, and may have conveyed germs there, especially as they were not passed through the flame, as the file was.‡ He defies them, if they take sufficient precautions, to obtain infusoria in all their flasks.§

MM. Jolly and Musset accept the defiance of M. Pasteur, Nov. 16,‖ and, in fact, on the 13th of June following, they send a memoir to the Academy, stating that they had returned to the Maladetta, this time with twenty-two flasks—that is, two more than were used by M. Pasteur—fulfilled all his conditions, not forgetting the pincers with long branches, properly heated, and found that infusoria appeared in every flask without exception in four days;¶ and so ended this part of the controversy.

The only conclusion I can draw from the numerous contradictory and ingenious communications presented to the Academy of Sciences during the last eight years on this matter is, that not the slightest proof is given by the chemists, with M. Pasteur at their head, that fermentation and putrefaction are necessarily dependent on living germs existing in the atmosphere. They rather tend to show that these are phenomena of a chemical nature, as was ably maintained by Liebig.** We must conclude, therefore, that living germs are not necessarily the cause of putrefaction and fermentation; neither is it necessary to believe that ferments are living at all—they may be dead. This, if not admitted, seems to be implied by Pasteur himself, who tells us he can now excite these processes, not by fresh yeast only, but

* "Comptes-Rendus," tome lvii. p. 558. † Ibid. p. 724.
‡ Ibid. p. 725. § Ibid. p. 726.
‖ Ibid. pp. 842-845. ¶ Ibid. tome lvi. p. 1122.
** "Letters on Chemistry," letters 18 and 19.

by the ashes of yeast.* That they may be induced by dead organic matter, which has been subjected to a direct temperature of 150° or 200° centigrade—a heat utterly incompatible with the existence of life—we have seen to have been proved by Pouchet, Jolly, Musset, and others. Whilst, then, the chemists have entirely failed in proving their case, the microscopical evidence is wholly opposed to the existence of atmospheric germs.

The idea that these imaginary germs were the cause of putrefaction, of disease, of blights among vegetables, and other evils, originated with Kircher and the pathologists of the seventeenth century. It has been frequently revived, but always shown to be erroneous. In 1852, cholera was supposed to be occasioned by a fungus that really existed in the dejections, but which Mr. Busk pointed out was the *uredo segetum* of diseased wheat, which entered the body in the form of bread. Certain well-known parasitic diseases are spread by contact, such as scabies, which, as it depends upon an insect burrowing in the skin, may be understood to crawl from one person to another. Favus, or scald head, which consists of a parasitic plant growing on the scalp, also, I succeeded, in 1841, in proving might be communicated to otherwise healthy persons; † but many of our unquestionably infectious diseases, such as smallpox, scarlatina, measles, and typhus, have no such origin. It has been attempted to be proved, indeed, by Lemaire,‡ that in the condensed vapours of hospitals and other putrid localities, vibrios may be found; but that vibrios are the cause of these various diseases, is not only not proved, but from what has been stated, is highly improbable.

What, then, it may be asked, is the origin of the infusoria, vegetable and animal, that we find in organic fluids during fermentation and putrefaction? In answer to this question, I answer they originate in oleo-albuminous molecules, which are formed in organic fluids, and which, floating to the surface, form the pellicle or proligerous matter. There, under the influence of varied conditions, such as temperature, light, chemical exchanges, density, pressure, and composition of atmospheric air, and of the fluid, &c., the molecules, by their coalescence, produce the lower forms of vegetable and animal life.

Hallier, describing the development of *Penicillium crustaceum*, tells us that, after all movement in the primary molecular mass has ceased, the molecules arrange themselves in long lines, which he calls Leptothrix chains (fig. 1, *f*). From the melting

* "Comptes-Rendus," tome lvi. pp. 418, 419.

† See the Author's paper on Parasitic Fungi.—"Trans. Royal Society of Edinburgh, 1842."

‡ "Comptes-Rendus," tome lix. pp. 317–428

together of these, the delicate filaments forming *Leptothrix buccalis* are evidently produced; and these, according to him, by further development, pass into *Penicillium crustaceum.* Why the molecules should sometimes arrange themselves in long rows, and at others into rounded masses (compare fig. 1, *f* and fig. 5, *a*), is probably dependent on varying degrees of limpidity and viscosity. But why both these forms of molecular matter should sometimes possess an inherent power of contractility, and at others not, it is impossible as yet even to surmise. But, on the determination of this point, the variations existing between the different kinds of fermentation and putrefaction are evidently dependent.

REVIEWS.

PROFESSOR OWEN'S ANATOMY.*

FOR more than two years we have waited patiently for the appearance of the volume completing Professor Owen's treatise on Vertebrate Anatomy, and now that it has been issued, we must confess to being disappointed with it as a whole. We do not mean to imply that the book which is now before us is inferior to those which have preceded it, or that it is devoid of value or interest. But we had expected to find in it that the author had done justice to those fellow-labourers in the field of science whom he had previously overlooked or misinterpreted, and we are sorry to see that our anticipations have been unfulfilled. Nay, more than this, we find the author still ignoring the labours of our ablest anatomists, still slurring over the grave objections that have been urged against his views, and still indulging that bitter invective and that caustic sarcasm which we are accustomed to look upon as indisseverable from his writings. Further, indeed, we perceive that he has gone out of his way to expend his vituperative powers in a most unfair attack upon ourselves, because, in common with the "London Reviewer," we were the first to show that he not only admitted the fact-basis of Mr. Darwin's theory, but even went so far as to lay claim to being the originator of the theory itself. It would be needless to attempt now any justification of the course we then adopted; the mere fact that in the last edition of his "Origin of Species" Mr. Darwin fully recognises our position is quite sufficient for us. If further explanation were required, it would be found in the very attack to which we refer, since Professor Owen's remarks, when divested of that obscurity characteristic of his singularly verbose mode of expression, adequately support the belief which we still contend for, that Professor Owen has admitted all facts on which the theory of natural selection is based. It is for the above reasons, then, that we confess our disappointment.

In an analysis of the portion of the volume devoted to anatomical considerations we shall be as brief as possible, avoiding quotation because of the author's wordy mode of description and inexact and tedious style. The third volume continues the subject of mammalian anatomy dealt with in the second, and treats upon the nervous, circulating, respiratory, alimentary,

* "The Anatomy of Vertebrates," Vol. III., Mammals. By Richard Owen, F.R.S. London: Longmans, 1868.

tegumentary, and generative systems, the subject of development being included under the last head. Besides the various chapters in which the anatomy is treated upon, there is a final chapter, in which Professor Owen lays down general conclusions, of wide range of application, of considerable interest, and in some instances of no little irrelevancy to the subject-matter of the work. Throughout the volume there is of course little that is new, seeing that the author has had to deal with points of structure already described in his various memoirs and communications to learned bodies. But there is even less of reference to recent researches than we had a right to expect from the Superintendent of the natural history department of the first scientific institution in the kingdom. Of all the anatomical chapters, that on the nervous system is, from its numerous associations with great biological problems, and from the well-known discrepancy between the author's opinion and the facts adduced by other anatomists, at once the most interesting and remarkable. Passing by Professor Owen's tendency to employ a terminology peculiarly his own, and by no means constant, we find one of the most striking features in this chapter to be a repetition of the opinions laid down before, in reference to the characteristics of the mammalian brain. Our readers are doubtless aware that Professor Owen has formed a classification of Mammalia based on the structure of the brain. He divides the mammals into four groups: 1. *Archencephala*, including man only, and especially characterised by the presence of a cerebrum which completely covers in the cerebellum. 2. *Gyrencephala*. The animals in this group have not this character of cerebrum covering the cerebellum, but then the two halves of the cerebrum are united by a commissure called "corpus callosum," and the convolutions are convoluted. 3. *Lissencephala*, in which, according to Professor Owen, the surface of the brain is smooth, but there is still a corpus callosum. And 4. *Lyencephala*, in which there is a negation of all the above characters: the cerebellum is uncovered by cerebrum, the latter is smooth, and there is no corpus callosum. This scheme of division was laid down some nine years ago by Professor Owen in a memoir before the Linnean Society, and the definition of the groups or subclasses was pretty nearly as we have given it. There is, however, in anatomy, as in all other sciences an improvement in 1868 on the knowledge of 1860, and in accordance with this improvement, it has been found necessary to reject very materially the grounds on which the author established this division of mammals. It might be thought that Professor Owen would have seen reason to alter his views too. Not so. True to the vulgar proverb, he has adhered with unusual tenacity to his views expressed nine years since. And meanwhile what are the changes in facts? These changes—the author denies some of them, but the whole world of anatomists is against him—are: 1. That the cerebrum of man is not the only one which covers the cerebellum, but that man holds this in common with certain Quadrumana—this Professor Owen admits; and 2. That certain lyencephalous mammals have an imperfect but still distinct corpus callosum—this Professor Owen denies. It is very curious then, bearing these statements in mind, to observe the overstrained analogies, the unfair force given to certain facts, the general special-pleading ingenuity, and withal the suppression of antagonistic observation, which the writer exhibits all through this chapter on the nervous

system. He advances no new facts, takes little cognizance of later inquirers, and nevertheless, with an audacity which no writer less gifted in weapons of fence would venture on, he urges the accuracy of this old system of classification. We cannot but regret this for the credit of English science abroad; for there is no intelligent foreigner, capable of reading Professor Owen's writings, who can fail to see that the brain-division of mammals is now the merest shred of a worn-out marasmic and all but defunct generalisation.

Of the other chapters in this third volume, we may say of them that they contain hardly anything that is not to be found in the original memoirs from which they seem to be taken bodily. Here and there, indeed, *en parenthèse*, we find a sneering reference to some opponent, or a foot-note explanatory of some new technicality, but beyond this nothing of special interest. The chapter on the digestive system, in which the teeth are classified and described, derives its highest interest from the circumstance that the author has adopted a rational system of classification, founded on development—a basis which, in nearly every other instance, he regards as unphilosophic. There is, too, in this chapter a feature of special import to the student of human histology; it relates to the question of the development of teeth, which latter, according to Professor Owen, are essentially dermic structures. This, as a contemporary has pointed out, arises from a misconception which the author, in common with numerous other anatomists, has fallen into. The true relations of the derma to the epidermis, and of both to what is styled the basement membrane, was first, if we remember aright, pointed out by Professor Huxley in his excellent article on "Tegumentary Appendages," in Todd's "Cyclopædia of Anatomy." Mr. Huxley there demonstrated that the skin consists of two strata, which become differentiated in opposite directions from a zone or belt of indifferent tissue (basement membrane), the outer one he called ecderon (epidermis), and the inner he termed enderon (derma). Taking this view of the homologies of the two structures (and it seems the only philosophical one), it is clear that the teeth would not be as Professor Owen represents them, purely dermal structures, but would come under the category of epidermal or *ecderonic* structures. The chapter on the circulatory system contains an account of the varied forms of apparatus employed in distributing the blood over the body of mammals, from the lowest group up to man. In this the author advances the opinion, which he says he urged many years ago, that the permanent or red globule of the human blood is derived by division from the white globule. He states that his observations on the blood corpuscle of Perameles "suggested the idea that such blood disc was undergoing a spontaneous subdivision into smaller vesicles," and he thinks that the researches of Dr. Roberts, of Manchester, and Mr. Wharton Jones bear out this view. But so far as the quotation from Dr. Roberts's paper, which the author gives, is concerned it is clear that the opinion held is very different from that of Professor Owen. The latter says that the white corpuscle itself divides, but Dr. Roberts, as cited by Professor Owen, evidently speaks of division of the nucleus, for he says, "a number of the nuclei were seen in the process of division * * * * There was evidence that these secondary nuclei were set free in the blood, and by subsequent enlargement," &c., "developed into red blood discs." Again, we may say on our own authority, that Mr. Wharton Jones's observations do not in the

faintest manner confirm this observation of the author's, as they go to prove that the red globule is the liberated *entire* nucleus of the white cospusclo. Indeed, this discovery of Professor Owen's seems to be altogether unique. There are many other points in the histology of this volume on which we think the text requires correction. Such are, for instance, the accounts of the structure of the liver, the spleen, and the skin.

The chapter on the development of the horns of mammals, and especially of the Cervidæ, contains a good deal of original matter, and suggests many curious problems for the speculative physiologist. The same may be said of the section devoted to the "peculiar glands of mammalia." The account of the development of the ovum is little more than an abridgement of the results of Von Bär's and Martin Barry's inquiries.

It is in the final chapter, which is headed "General Conclusions," that the author shows himself to most and least advantage, and in which he discusses all the great questions which have been such bones of contention among naturalists almost since the time of Cuvier, and especially within the last ten or fifteen years. Teleology, origin and extinction of species, the law of derivation, and Mr. Darwin, are here dealt with briefly and with vigour, and in the last couple of pages the author declares himself the champion of spontaneous generation, and analyses the soul to an extent which will hardly satisfy divines. It is very difficult for one unpossessed of Professor Owen's higher intelligence to grasp what it is exactly that the author *does* believe in; and if, therefore, we once more misinterpret (?) him we must beg his pardon and plead his complexity of style as our excuse. But so far as we can gather from his pages, Professor Owen pushes the question raised by naturalists just one stage back and no more. He denies the successive creation of types; he admits the formation of new groups as a result of variation, but he contends that all this is the operation of a definite law which was first established by the Creator. He thus, to our minds, differs but very little from the disciples of Mr. Darwin, save that he holds that natural selection is inadecuate to explain the preservation of species, whilst he offers no alternative explanation of his own. Clearly the distinction between the author and Mr. Darwin is in the rendering of the term "natural selection." Professor Owen wittingly misconstrues Mr. Darwin's conception of the expression, and will persist in asserting that Mr. Darwin personifies nature as an intelligent entity. This is wrong; and it is grossly unfair to Mr. Darwin, who simply employed the word as a convenient mode of expressing a number of phenomena called "natural." We think, therefore, that Professor Owen, who but two and a half years ago laid claim to being the originator of the principle on which the theory of natural selection is based, stands, by a series of admissions, convicted of Darwinianism. Whether Mr. Darwin will welcome him among his numerous converts remains to be seen. Of one thing we are quite convinced, that if the charge of temerity may be urged against Mr. Darwin for advancing an hypothesis he cannot demonstrate, it may with tenfold more justice be brought against the author. In the very page on which he repudiates natural selection as without basis in fact, he himself starts the profoundly ridiculous theory that the horse and donkey were predestined and prepared for man, because the Creator felt that the two latter were essential to man's welfare and civilization, assigning as an argu-

ment for this preposterous speculation, his own emotions on entering "the saddling ground at Epsom before the start for the Derby." Will Professor Owen tell us whether he thinks the steam engine, and the compass, and the electric telegraph were prepared and destined in a similar manner, and if not, where he discerns that superior intelligence which selected the former set of influences rather than the latter?

The most startling phase of the author's mental development is that which unfolds itself in his open conviction of the views of M. Pouchet. This will pain and surprise not a few of his "creationist" supporters considerably. Yet we think it is the one "saving clause" in the volume, the one redeeming feature of a work which, however comprehensive, is so full of objectionable features that we trust it may not be accepted abroad as the reflex of British science. We are certainly of opinion that on this one point of spontaneous generation Professor Owen has allowed his mind to arrive at an unbiassed conclusion, and in this solitary instance we think he is in advance of his *confrères* in this country, with the single exception of Dr. Hughes Bennett of Edinburgh, whose able essay in our present number is in great measure a demonstration of the principle of heterogeny. Professor Owen speaks his mind openly and honestly on this question, and lends the weight of his authority to the side of heterodoxy. But it is heterodoxy which we do not think we go too far in asserting will soon be very generally accepted. Looking at the work which Professor Owen has just completed as a whole we must say, as we did at first, that it disappoints us. On the other hand, we are bound to confess that it contains a huge store of anatomical facts, and that once the reader has mastered Professor Owen's style he will find a peculiar fascination in the book.

THE STUDY OF INSECTS.*

DR. PACKARD, who is a constant contributor to the pages of our interesting contemporary, the *American Naturalist*, and who is a careful student of insect-life and structure, has in the work now published given us not only a guide to the study of insects zoologically, but a very excellent anatomical treatise on the class Insecta. In addition, he has offered some remarks of great practical value on the insects injurious and beneficial to crops. The illustrations, which, like those of most American works on Zoology, are printed in white on a black ground, are both handsome and accurate, and in some instances are taken from the fine memoir presented last year to the Boston Natural History Society by Professor Wyman. The account of the development of the ovum seems to us to be exceedingly well and intelligibly stated. The author has not merely transferred the statement of some text book to his pages, but has drawn abundantly on his own original observations, and has made frequent reference to the valuable investigations of Zaddach and Rathke. We wish we had space at our disposal

* "A Guide to the Study of Insects," by A. S. Packard, jun., M.D. Salem, U.S. 1868.

to do justice to the author by quoting from his descriptions, but as we cannot we must be content with expressing our entire and unqualified approval of his labours. In the second part of his work he treats upon the geographical distribution of insects, their diseases, their habits and variations, and gives ample instructions (the best we have met with) as to their capture and preservation. Finally, he supplies a most comprehensive entomological bibliography, which he arranges under the heads of General Works, Morphology, Anatomy and Physiology, Embryology, Fossil Insects, and Periodical Works now in course of publication. The illustrations intercalated with the letter-press are more than seventy in number, and there are several handsome page plates. Type and paper have the usual excellent qualities of American books. Altogether, we are immensely pleased with this work. It is assuredly all in all the fullest, most modern, and most clearly-written treatise on insects we have ever seen, and we heartily commend it to our readers' notice, feeling certain their judgment of its merits will not be less favourable than our own.

HEAT AND CHEMISTRY *

STUDENTS who are going up for the matriculation pass examination of the University of London, are examined in certain branches of Physical Science, and among others, in the departments which form the above heading. It is for the readers of this class that the author of the manual under notice has attempted to provide. Mr. Guthrie evidently thinks that even elementary treatises like those of Balfour Stewart are of too difficult a character, and that works like that of Lardner are too general for the requirements of the London University. He has therefore attempted to compile a book which, while avoiding the mathematical details of higher treatises, should bring together, in clear and intelligible language, the leading phenomena and laws of heat and of non-metallic chemistry. His endeavours have been in some measure successful, and in some degree also have failed in their purpose. For instance, while he has treated the subject of heat in accordance with the aim he had in view, he has fallen short of his aim in dealing with the chemistry of the non-metallic elements. This statement of ours applies both absolutely and relatively—the physics is better than the chemistry; and while the former, though general, is accurate and tolerably well in keeping with recent research, the latter is in all respects an imperfect labour. The mode of arrangement pursued in treating upon both subjects is the convenient one of separate, numbered paragraphs; and these latter are all the more useful to the student from the fact that the author has appended a number of examination questions, the numbers following which, are those of the paragraphs in which the substance of the answers is to be found. We question whether the author's definition of heat—"that it is the force which tends to cause the change in the temperature of bodies"—is as thoroughly satisfactory as our knowledge of tem-

* "The Elements of Heat and of Non-metallic Chemistry." By Frederick Guthrie, B.A. (Lond.), Ph.D., F.R.S.E. London: Van Voorst. 1868.

perature phenomena would enable us to construct; but perhaps it is more easily comprehended by the student than any more lengthy definition involving a reference to the vibrations of matter. The chemical part of the book is not at all what it ought to have been. Mr. Guthrie must surely be aware that neither in the University of London, nor in any of our metropolitan lecture theatres, is either his nomenclature or his notation likely to be received with favour. If Mr. Guthrie would be counselled by us, he would immediately set about the revision of this book; and if he does, he will no doubt produce a clear, accurate, and useful handbook for candidates for the London University matriculations.

ARTIFICIAL SELECTION AMONG MEN.*

THAT the Anthropological Society of London should not exclusively confine its inquiries to man as he has been, but should give a little attention to the human race as it might be, is the view herein expressed by Mr. Bray. Whatever may be the force of this opinion, it does not follow from its reasonableness that it must necessarily fall exclusively to the F.S.A.L.s for its solution. Indeed, we see no reason why the problem should not be discussed generally in many other natural science bodies. But we fear that in the present condition of our social system there is an impassable barrier to researches such as that Mr. Bray suggests, so far at least as their practical application is concerned. And it is only by practical experiment that such questions as that of the improvement of the human race by artificial selection can be satisfactorily decided. It is for this reason that Mr. Bray's proposal strikes us as being extravagantly Utopian. It is from this circumstance also that we refuse to discuss it in our pages. We do not, however, on that account reject Mr. Bray's idea as one unworthy of consideration in the abstract. So far from this, indeed, we think that those who are versed in the doctrines of modern philosophy; those who have already seen the absurdity of those unreal entities called Pneuma and Phusis and Psuke will read the author's remarks with a conviction that there is something in his theory. And even if they do not go so far, they cannot but derive pleasure from reading his forcible English, and profit from pondering on his very suggestive remarks on the physics of metaphysics, if we may use such an Hibernianism. The one blemish which the author shows, is his somewhat irrational advocacy of Gall's Phrenology. This surprises us considerably, for Mr. Bray has paid no small degree of attention to some of our finest works on Physiology and Psychology, and we can only regard it as one of those prejudices which are often parasitic on even abler brains than his.

* "The Science of Man: a Birds eye View of the wide and fertile Field of Anthropology." By Charles Bray. London: Longmans, 1868.

THE EAST INDIAN ARCHIPELAGO.*

IT may be fairly laid down as a proposition to which there are very few exceptions, that books of travel contain a small amount of novel matter, diluted with an enormous quantity of vapid personal detail and ill-digested personal reflection. This is especially true of works on Africa, but it holds good for nearly all geographical literature, and we fear that it is in some measure applicable to the handsome volume which Mr. Murray has just issued. We would not be understood to imply that Mr. Bickmore has not added to our knowledge of the extremely interesting country he has travelled in, but we feel we are thoroughly justified in affirming that everything new in his narrative might easily have been stated in thirty or forty pages of the five or six hundred of which his book consists. The author went out, he tells us in his preface, to Amboina, to re-collect the shells figured in Rumphius' "Rariteit Kamer;" and it is, in our opinion, to be regretted that he did not confine his published observations to the scientific points which came under his notice. In fact, Mr. Bickmore has given us an account of a scientific exploration, which has been productive of little or no scientific results. It is most irritating, in reading this work, to find how many splendid opportunities of research have been overlooked in the desire to run rapidly over a huge tract of country, and in the effort to record sensational superficialities. When we find a couple of our own countrymen going on a two months' voyage to the Faroe Islands, and bringing us home facts and suggestions which throw light on a hundred scientific problems, it is with a feeling of inexpressible contempt that we accept the paltry results which the author of the present volume has with wearisome monotony of style spread out over nearly 600 pages. When we think of what Darwin or Edward Forbes would have learned in the course of an expedition like that of Mr. Bickmore, we cannot congratulate "the friends of Science in Boston and Cambridge" on their success in selecting the author to add to our scientific knowledge of the great Eastern Archipelago. As a pleasant book of adventure for those who know little or nothing of this part of the world, we can commend the volume; as a luxuriously illustrated and ornamental appendage to the drawing-room table, we can speak equally well of it; but as an addition to scientific literature it has little or no value. We have often in these pages protested against the petty self-vanity of travellers, who on every page of their works parade the common-place incidents of their domestic life before their readers, and who so often inflict upon us their efforts at "magnificent composition." But it would seem as if all travellers were alike, and Mr. Bickmore must be added to those who have gone before him. There are numerous references in his Travels to scientific points of interest, and there is a list of birds given in the Appendix, but we find without exception that the problem or the observation or the

* "Travels in the East Indian Archipelago." By Albert S. Bickmore, M.A., Fellow of the Geographical Society of London, Professor of Natural History in Madison University, Hamilton, New York. London: John Murray, 1868.

phenomenon referred to in the text is deserted *in limine*, and that the author thrusts it aside to tell us of his own thoughts or of some other equally uninteresting or unprofitable subject. By the way, we would suggest it as a metaphysical problem for those curious in these matters, why it is that when a man makes a voyage, and writes a book describing it, he fancies that the dreary recital of his breakfasts and his suppers, his emotions excited by the beautiful, and wordy sentimentality that he would under other circumstances ridicule, prove a fascination sufficient to induce one to wade through some hundred pages of prolonged weariness? If anyone could solve this, and propose a remedy, he ought to have a statue. To Mr. Murray our thanks are due for nearly forty handsome plates, which delineate numerous interesting, though hardly novel objects.

POPULAR OPTICS.*

NOTWITHSTANDING the very high opinion that we hold and that we have frequently expressed concerning scientific investigation in America, we must confess that the handbooks published by our brethren at the other side of the Atlantic are anything but representative of the present state of science. We find that is the case in nearly every department of science, so much so that it might be said that the best scientific treatises used by the Americans are reprints of English works. Is it not then a question whether the absence of an international copyright law is not the cause of this? American publishers find it cheaper to print good English books for which they pay nothing, than to add an author's to a printer's bill. These reflections are suggested by Mr. Nugent's "Treatise on Optics," a book of which we can only say, that if it represents the knowledge of the laws of light in America, American science must be at a very low ebb. We have never in the whole course of our career of criticism met with so imperfect a work as this; it is elementary without being clear, diffuse without being comprehensive. It contains no reference to the more modern applications of optics, and its account of the physiology of vision is simply ridiculous. The author alleges that such a treatise as his "has long been a desideratum" for schools and colleges. This alone shows how little he knows of the literature of the subject. With such excellent works as Galbraith and Haughton's "Manual," and Ganot's Physics, Golding Bird's, Arnott's, and Lardner's general treatises, we think our schools have been very much better cared for than Mr. Nugent suspects. Such books as those named are in every respect superior both in clearness of style, appropriateness of illustration, and reference to recent progress, than the work upon our table. Mr. Nugent's diagrams are in many cases quite antique, and, save in the photographic section, are insufficient. The following paragraph, containing the author's hypothesis of "adaptation," is a sample of this work, and is

* "A Treatise on Optics; or, Light and Sight Theoretically and Practically treated." By E. Nugent, C.E., ex-Principal of Commercial, Nautical, and Engineering College, New York. London: Virtue.

a piece of Partingtonism of the worst style: "I am strongly inclined to think that the eye adapts itself to different distances by a sort of galvanic or electric action (!) induced in it by the stimulus of light proceeding from external objects; the force of this action depending upon the distance from which the light proceeds, the intensity of the light," &c. This is certainly an explanation, but it hardly enlightens us much. The most interesting department of modern optics, that of Spectroscopy, has been left untouched, and altogether the book is a feeble and unsatisfactory production.

FOWNES'S CHEMISTRY.*

FOWNES'S CHEMISTRY had been so long the recognised text-book, at all events in medical schools, that it was with regret we found that its later editions were less suitable for the lecturer's or teacher's purpose than they should have been. Within the last ten years the science of chemistry has undergone such a change, that many who laid their foundation of knowledge in this department in 1858 would, if they were to dip into a treatise of to-day, find it in many points quite unintelligible. Fownes's Manual had not kept pace with the age, and consequently it had for some years fallen into a little disrepute. In the present edition it regains its former high standing, and though the volume which Mr. Watts and Dr. Bence Jones have now given us extends over more than a thousand pages, and is therefore no small labour for the student who would master its contents, it must be said to be unquestionably the best hand-book in our language. The plan of the present edition is much the same as before. The first part of the book is devoted to physics, the second to inorganic, and the third to organic chemistry. The terminology is that now universally employed both in this country and abroad, and the notation is the same as that used in Watts's Dictionary, and very generally adopted among English chemists. The physical portion is the weakest part of the book, yet it is excellently done, and it includes reference to most of the new facts in natural philosophy. The subjects of electrical resistance and spectrum analysis might, perhaps, have been more fully given, but this is not of much importance. The chemical division of the work is admirable; especially so is the lucid and forcible chapter on chemical philosophy, which Mr. Watts has entirely re-written. The greater part of the organic chemistry is new, especially the sections on the hydrocarbons, alcohols, and acids. We have not space to refer to the system of classification adopted by the Editors, nor can we point out the many typographical errors which we have discovered. We must, therefore, conclude with a hope that the publisher may issue a list of errata, and a conviction that the student who possesses this manual is armed against all the contingencies of modern examinations in chemistry. "Fownes's Manual," as it is popularly styled, is clear, comprehensive, modern, and easy of reference.

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* "A Manual of Chemistry, Theoretical and Practical," by George Fownes, F.R.S., late Professor of Chemistry in University College, London. Tenth edition. London: Churchill, 1868.

PHYSIOLOGICAL ESSAYS.*

THE Reviews which appear now-a-days in some of our heavy artillery of literature, partake more of the essay than the critique. Indeed, folk have come so much to disregard the criticism of writers, and to form their own judgment on books, that anything like a lengthy critical survey of a work would be received with disfavour and would be detrimental to the welfare of the journal in which it appeared. People like to read something that interests them, and if a notice of a book is a long one, it will not be read unless it is something more than a notice. Hence it is the custom for a reviewer to (1) select a "taking title;" (2) then to labour with scissors and paste to disembowel a number of books and so construct, by ingenious dove-tailing of quotations, a readable essay, and (3) to make a foot-note of the titles of the mutilated works, and finally serve up, as the cookery books say, with a little preliminary garnish. Of this kind of stuff is our modern Quarterly Review. In the book upon our table, Dr. Child reprints such a series of essays and offers them in collected form to the public. We can say of them that they are interesting and even instructive, but that they are critical we do distinctly deny. Even when they display an air of criticism as in the review (?) of the "Memoirs on Heterogeny," it is clearly the criticism of foregone conclusions and not of an impartial examination. Dr. Child's volume is pleasant reading, but it is a type of book of which we cannot approve.

SHADOW PERSPECTIVE.†

THE term Sciography is used to designate the science by which the shadows thrown by bodies illuminated from a certain point can be determined with geometrical exactitude. It is a science which as yet has been almost entirely unworked, and which we think ought, in art, to be productive of very good results. The perspective of form is already pretty accurately understood by artists, but the perspective of shadow is in most cases arrived at as a result of experimental teaching, and is expressed much in the same way as the student who when asked "on a right line to construct an equilateral triangle," set about doing it with a pencil and tape-measure. In the very clever work which Dr. Puckett has prepared, the art and science of shadow perspective are fully given and amply illustrated. The author has given a scientific basis to his propositions, and has done more for this branch of art than can be just yet realised by the body to whom he addresses himself. We commend his book to all who are interested in accurate drawing.

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* "Essays on Physiological Subjects." By Gilbert W. Child, M.D. of Exeter College, Oxford. London: Longmans, 1868.

† "Sciography; or, the Radial projection of Shadows. By R. Campbell Puckett, Ph.D., Head Master of the Bath School of Art. London: Chapman and Hall. 1868.

SEA-SICKNESS.*

DR. CHAPMAN has here enlarged his pamphlet on the use of the spinal ice-bag in the treatment of sea-sickness, and in doing so he has added fresh cases to his record and has considerably extended his observations on the physiological aspects of neuro-therapeutics. So far as the author's *à priori* arguments are concerned we consider them unsound—not more so than the great mass of such physiological reasoning, but dangerous, because all hypothetical arguments—and they are of this order—are objectionable. They are ingeniously put, and there is a categorical sequence about them which is pleasing, but they show many fallacies. For instance, we might remark in answer to Dr. Chapman's belief that ice applied to the spine diminishes the temperature of the sympathetic ganglia, that this statement is an assumption without a shadow of proof. It may be a convenient hypothesis, but we could urge very different hypotheses which would meet the facts just as well. Indeed, it seems to us extremely improbable that ice applied to the spine can have any such effect. We might raise similar objections to many others of Dr. Chapman's physiological views, but we refrain from doing so, because we think that his system of therapeutics must be taken as an empirical fact, and judged on its own merits. Now we have no experience of our own to offer on the subject, but we must confess that there seems to be more in Dr. Chapman's mode of treatment than some physicians will allow. The cases that the author records are both numerous and authentic, and though cases do not always prove the value of a therapeutic method, yet they should induce us to give Dr. Chapman's plan a trial. This is what we would ask of our professional readers. The cases reported in the present work are of much interest, and they certainly go far to assure us of the active influence of the spinal ice-bag in relieving the symptoms of sea-sickness. Dr. Chapman writes with a force and vigour not always found in medical works, and even those who differ from him in opinion will find his book both clever and attractive.

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* "Sea-sickness and how to prevent it," &c. By John Chapman, M.D., M.R.C.P. Second edition. London: Trübner, 1868.

SCIENTIFIC SUMMARY.

ASTRONOMY.

THE *Solar Prominences.*—One of the most interesting discoveries ever effected by astronomers has recently rewarded Mr. J. Norman Lockyer's spectroscopic researches. On a reference to our Summary of Astronomy for January 1867 (No. 22), it will be seen that more than two years ago Mr. Lockyer applied the spectroscope to the analysis of the solar spots, and that with such success as to enable him to refute the views which M. Faye had expressed respecting the nature of the spots, and to establish on a sufficiently firm and stable basis those which had been held by Messrs. De la Rue, Balfour Stewart, and Loëwy. In the paper in which these results were presented to the Royal Society, Mr. Lockyer suggested the possibility that the spectroscope might be applied to search for the spectra of the prominences. As the bright lines due to the burning hydrogen around the star T Coronæ were rendered visible to our spectroscopists, he held that if the prominences are due to any similar cause we ought to be able to detect their bright lines by the same means. With the instrument he then made use of, however, Mr. Lockyer was unable to detect any trace of the spectra of the red prominences. Mr. Huggins also, with his 8-inch equatorial and the powerful spectroscopic apparatus made use of in his physical researches, could detect no sign of the prominences, nor could Mr. Stone with the great equatorial of the Greenwich Observatory. An instrument was being prepared for Mr. Lockyer, by Mr. Browning, the optician, which was to be specially adapted to the search for the spectrum of the prominences. Before this instrument had been rendered available, however, news came from India that the true nature of the prominences had been detected. These objects, as we mentioned in our last summary, were proved to be gaseous. Accordingly, it became clear that there was a possibility of seeing the spectrum by full daylight. Let us consider *why* this is so: There is a little difficulty about the subject, as will be shown by the fact that at a recent meeting of the Astronomical Society, the Astronomer-Royal expressed his inability to see why the spectroscope can render the light of the prominence-spectra visible in the neighbourhood of the strong solar spectrum. We know that no means which have yet been devised have rendered the prominences visible. If we darken the sun we blot them out; if we hide the body of the sun by any artificial means, we still leave the illuminated atmosphere, and this is quite sufficient to obliterate the prominences. Now, since the reduction of

the sun's light, accompanied as it necessarily must be with the reduction of the light of the prominences, does not bring them into view, it may be asked why spectroscopic analysis should avail to that end. The formation of an ordinary solar spectrum is merely a mode of reducing the intensity of the sun's light by dispersing it over a wider area than it would otherwise occupy. Hence, it is quite clear that if the spectrum of the prominences were similarly dispersed we should gain nothing by this mode, more than by any other mode of reducing the light both of the sun and of a prominence. But the spectrum of the prominences is *not dispersed*; on the contrary, all the light is gathered into three fine lines. Therefore the spectroscope allows us to do what is not possible in any other way; namely, to reduce the light of the photosphere without reducing the light of the prominences. Hence we are enabled to see the spectrum of a prominence side by side with the solar spectrum.

But now we have to record one of those singular and somewhat annoying coincidences which have so often marked the progress of astronomical inquiry. The idea which had occurred to Mr. Lockyer, occurred also to M. Janssen (the head of the French expedition sent out to view the eclipse) so soon as he had discovered that the prominences are gaseous. The eclipse, it will be remembered, took place on August 18; M. Janssen formed his views on the same day, applied them on the next, and thus, within thirty hours, solved the problem over which Mr. Lockyer (through no fault of his own, however, be it remarked) had been engaged upwards of two years. Janssen's discovery of the visibility of the prominence-spectra when the sun is not eclipsed, preceded Mr. Lockyer's by two months. But the claim of the latter to the independent solution of a problem, which, so far as we know, he was the first to suggest, was not invalidated; because M. Janssen's letter announcing the discovery did not reach the French Academy of Sciences until after a full account of Mr. Lockyer's processes had been read before that body. By a singular coincidence it arrived a few minutes after. Without pretending to settle the rival claims of the English and French astronomers to a discovery which, if not one of the most important, is at least one of the most interesting, ever made, we may remark that, if on the one hand we cannot but admire the steady perseverance with which Mr. Lockyer clung to the notion which had occurred to him, and persistently pursued his observations till they had been rewarded by success; on the other, we are filled with admiration at the Napoleonic rapidity with which the French astronomer grasped the bearings of the problem, conceived the mode of solving it, and carried out that solution to the successful end.

One interesting feature of the discovery remains to be noticed. When the spectrum of a prominence is observed by the new method, it is seen in direct contact with the continuous solar spectrum; and thus it becomes possible to determine the coincidence or non-coincidence of the bright lines of the prominence-spectrum with any of the dark lines of the solar spectrum. In this way it has been shown that the red line of the former spectrum agrees exactly with the line C (a hydrogen line) of the solar spectrum; the orange line, however, is not coincident with (though near to) the dark line D (the double sodium line) of the solar spectrum; lastly, the greenish-blue line of the prominence-spectrum very nearly agrees with

the line F (a hydrogen line) of the solar spectrum. We must confess, however, that we are rather perplexed by this result. We may be ready to reject the view that the orange line is due to the existence of sodium in the flames which surround the sun; but the exact coincidence of the red line with the solar line C compels us to believe that these flames consist in part of burning hydrogen: this being so, how is it that the green line of hydrogen is not seen, though one very near to it makes its appearance? In the spectra of the nebulæ the green line F of hydrogen *is* seen, while the red line C is not seen. This phenomenon, though perplexing, is not so perplexing as that presented by the prominence-spectra. Is it possible that the two phenomena may be in a sense correlative; that hydrogen is in reality a compound substance, and that the line C belongs to the spectrum of one of its elements, the line F to that of another?

The Transit of Mercury.—This phenomenon was well observed by many of our leading astronomers; amongst others, by Messrs. Stone, Dunkin, Lassell, Huggins, Professor Smyth, Captain Noble, and Mr. Browning. We have little to add to what is already known respecting Mercury. Some observers (amongst others Mr. Huggins with his fine 8-inch refractor) saw one spot; others (including Mr. Browning, with his great 12½-inch reflector) saw two; and Mr. Stone (with the great Greenwich equatorial of 12¾-inch aperture) saw none. It appears to us that this diversity proves beyond dispute that the phenemonon is purely optical. On the other hand, Mr. Huggins noticed that a ring of light could be seen round the planet even when a very strong darkening glass was made use of. This would seem to show that the ring has a real existence; though it is still possible that the appearance may be due to irradiation. One observation of the transit strikes us as important. All the observers we have named noticed an apparent change of figure in Mercury as the planet approached the edge of the sun's disc; but Mr. Henry Pratt, who observed the phenomenon by projecting the solar image on a screen of finest white cardboard placed in a darkened room, noticed that the last internal contact took place without the slightest appearance of elongation or distortion in the shape of the planet's disc. This circumstance seems to suggest important considerations with respect to the observation of the transits of Venus in 1874 and 1882.

The November Shooting-Stars.—Contrary to the general expectation of astronomers, the November star-shower was well seen in England. The display lasted until five in the morning of November 14, having commenced shortly before midnight. The display was also well seen in America, at about 11 o'clock, local time, corresponding (for the eastern parts of the United States) to the hour at which the display ceased in England. The visibility of the display, after all that had been predicted by astronomers, suffices to show that we are not nearly so well acquainted with the habitudes of the meteoric system as we had imagined ourselves to be. Probably many years will elapse before we shall be able to predict the character and extent of an approaching shower, and the places at which it will be visible.

The majority of the meteors seen this year were orange, but a few presented a blueish light.

The Sun's Distance.—Astronomers have long been discontented with the explanations which have been put forward from time to time, to account for

the want of agreement between the determination of the sun's distance, founded on the transit of 1769, and the results which Hansen, Leverrier, Stone, Winnecke, and Foucault, have deduced from a variety of other methods. It was easy to show that the difference, although it amounted to three or four millions of miles, yet corresponded to an almost infinitesimally small error in the estimate of the solar parallax. But then the method founded on the transit of Venus is precisely such a one as should serve to get rid even of so minute an error as this. And indeed the fact that astronomers had been in the habit of stating the sun's parallax as $8''\cdot5776$ showed that they looked on the result as trustworthy to at least the third decimal place; whereas the mean of modern measurements gives the parallax as $8''\cdot9$. It is satisfactory to find that the whole error of the computation founded on the observations made in 1769 may be laid on the effects of the peculiar phenomena which attend the egress of a transiting planet. Professor Simon Newcombe had done a good deal towards the solution of the problem; but we believe that the credit of completely accounting for all the observations of 1769 in a consistent manner, with a result according closely with that obtained in recent times, must be assigned to Mr. Stone. In a paper lately read before the Astronomical Society, he shows that by taking the mean between the "formation of the black drop" which precedes the second internal contact and the apparent moment of real contact, and doing the like for the first internal contact, a result is obtained agreeing perfectly with the mean of the determinations obtained by other methods. The discovery is important in itself, and doubly important just now, as showing what is the principal point to be attended to in the observations which are to be made on the transits of 1874 and 1882.

The Planets.—Mercury will be well situated for observation as an evening star towards the end of January and until nearly the middle of February. Venus will be a morning star throughout the three next months, and well situated for observation in January. Mars will be well placed during the next quarter, coming to opposition on February 13. His path between the two stationary points lies in Leo, being almost equally divided opposite the bright star Regulus. On the day of opposition he will be near η Leonis. Neither Jupiter nor Saturn are very favourably situated for observation during the next quarter. Throughout January and February, Uranus will be well situated, and will be an interesting object for those possessed of first-class instruments.

Eclipse of the Moon.—There will be a partial eclipse of the moon early in the morning on January 28. The eclipse begins one minute before half-past twelve, and will end at 2 h. 47 m. A.M. The greatest phase takes place at 1 h. 38 m. A.M., when rather less than half the moon's diameter will be obscured. Interest would attach to the careful spectroscopic analysis of the moon's light during this eclipse, and we trust our observers will not lose the opportunity thus afforded them.

BOTANY.

The Ordeal Poison-Nut of Madagascar.—A description of the *Tanghinia veneniflua*, which is now naturalised in New South Wales, is given by Dr. Bennett in the *Journal of Botany* for October. The largest and finest tree in the Sydney Botanic Gardens is twenty feet in height, with a circumference of the branches full fifty feet. It flowers in November and December, and is often observed at the same time covered with fruit in different stages of maturity produced from the blossoms of the preceding year. The flower-buds are of a beautiful crimson colour; and, when expanded, the corolla is white, with the edges and under surface tinged with crimson; the flowers are very fragrant, and their odour is retained for some time after they are withered. The fruit is oviform and about the size of a hen's egg; it contains a hard stone or nut, enveloped in a dense fibrous substance. On this fibrous part being removed, there is seen a dark-brown shell, which, on being opened, is found to contain a white kernel, in size and appearance like an almond, and of a slightly bitter flavour. The fruit is at first of a green colour, then changes to a purplish-red tint on one side, but when fully ripe becomes wrinkled, and the entire fruit assumes a deep purplish-red colour. The whole of the tree yields a quantity of milky juice, very adhesive, and of a sweet creamy taste.

The Potentilla Norvegica in England.—Mr. G. S. Gibson has found this growing in Burwell Fen. He says it did not extend far, but was scattered around some thirty to fifty feet. It appeared quite at home, and at any rate must have been there for years. The plant is inconspicuous and likely to be passed over, except when in flower.

Cinchona Bark from Eastern Bolivia.—On the 1st of October a cargo of bark was sold in London at from ten to twenty-five per cent. above the ordinary prices of the best Bolivian bark. Hitherto the large mountainous tracts of this district have been practically of no value, though producing quinine-yielding barks to perfection, because of the supposed impossibility of finding any means of communication from them to the sea for the purposes of commerce. This, however, seems now to have been overcome by Senor Pedro Rada, who brought his cargo across the continent and to this country by way of Pará and Liverpool. Mr. J. E. Howard states in the *Journal of Botany* for November, that the specimens of bark received by him from Senor Rada agree with those of the *morada* and the *zamba* (or *negra*) and *zambita* (or *negrilla*) collected by Dr. Weddell in his last journey in Bolivia.

A peculiar Carpical Structure in Elæagnus gonyanthes.—In this plant, which grows abundantly in thickets of a rocky islet in Macao harbour, the accrescent, carnose, perigone-tube, covering the fruit, is most densely clothed inside with a close long white silky cotton, matted together into a pannose structure, so as to resemble more than anything else the cocoons of "shepherd-spiders." This web has not the slightest attachment to the putamen. —Dr. Hance in the *Journal of Botany* for December.

A Seaweed new to the British Flora.—*The Elachista stellaris* of Areschong's "Dried Scandinavian Algæ" has been discovered growing on *Arthoclodia*, on the Cardigan Bay side of the Carnarvonshire promontory at Pwllheli,

and four miles further west at Llandwrog. *Elachista stellaris* is known from all the species of the genus by the filaments being nearly simple, radiating from a small, dense, hemispherical tubercle; the threads are rather narrowed below, and very much attenuated and produced into a long slender tip above; the joints of the lower part of the thread are as wide as long, and of the upper part two or three times as long as wide; the spore is oval shortly pedicelled.—Dr. Gray in *Annals of Natural History* for December.

The Adulteration of Tobacco.—The *Journal of the Quekett Club* for October contains a paper on this subject by Mr. J. A. Archer. There is little that is new pointed out by the author, but the paper is, nevertheless, an interesting and useful summary of our knowledge of the varieties of adulteration and of the modes of detecting them.

Germination of the Spores of Varicellaria.—Dr. W. Nylander's observations on this point have been translated for the *Annals of Natural History* (December) by the Rev. W. A. Leighton, and are of interest. The spores of Varicellaria, which are the largest spores of all lichens, were placed by him in a humid atmosphere, and—as seen by De Bary and others—were soon covered with slender circumradiant filaments. In the course of a month or so these filaments acquired a mucedinous character, and produced moniliform hyaline penicillate acrospores, and thus constituted a slender *penicillium*. This subsequently disappears under culture. But before it disappears, he has observed in the endospore a hyaline protoplasm turbid in the middle, composed of very minute white granulations, which as it were by coagulation formed a solid white corpuscle in the cavity of each cell of the spore, and that this afterwards gradually increased after the fashion of an embryo, and at length in the third month filled the entire cavities of both cells of the endospore. At the same time, the wall of the two cells showed the concentric strata to have become sensibly looser, and was fissured by several fine transverse rimulæ preparing for its future dissolution, which a parasitic mucedinous vegetation would also promote. Dr. Nylander has noticed these phenomena from March till June. Then the spores denuded of *penicillium*, show a white corpuscle in each cell which distends the spiral wall, and ultimately expels an oblong corpuscle which, when free, enlarges, and is most probably the commencement of the thallus of the lichen.

The Morphology of Malvales.—We have received from Dr. Masters a copy of his paper on this subject in the *Linnean Society's Journal* (vol. x. Botany). Having examined very carefully the relation of the families *Malvaceæ*, *Sterculiaceæ*, and *Tiliaceæ* of Bentham and Hooker's Cohors VI., he has arrived at the conclusion that though it may be desirable for convenience sake to separate the two former from each other, yet that they are so closely related in morphological construction that it is hardly possible to comprehend the peculiar structural relations of the one without comparing them with the corresponding parts of the others. Dr. Masters looks on the stamens as being the organs of greatest importance in classification. Not only, he says, does the connection of the stamens furnish one of the best characters of the entire group, but even in the discrimination of the smaller sub-divisions (genera) the appearances presented by the column are of the greatest value.

A Synopsis of the South African Restiaceæ is the title of another excellent

paper in the above journal, by Dr. Masters. This extends over seventy pages, is illustrated by two plates drawn by Fitch, and is an important monograph in continuation of researches already published in the *Linnean Journal* by the author.

How Fern spores are scattered.—An American botanist, Dr. W. L. Wells, has been studying the phenomena of rupture of the sporangium of *Polypodium vulgare.* Under the microscope the sporangium could be seen to open at a point near its stem, and the opening grew very slowly larger until the continuation of the stem which previously encircled the sporangium was nearly straight. It then suddenly shut with a jerk, scattering the spores in every direction, and generally sending the sporangium itself out of focus. In the cases in which it was not thrown entirely out of focus, the same operation could be seen to be repeated two or three times. In no case were any spores scattered during the opening, which always took place very slowly.

Diœcism in Epigæa repens.—In the Proc. of the Academy of Nat. Science of Philadelphia, Mr. Thomas Meehan speculates on the fact which he has observed of the practical diœcism of Epigæa repens, the hermaphrodite flowers proving sterile. There would seem, he says, to be two distinct principles in relation to form going along together with the life of a species. The tendency of the one force is to preserve the existing form; the other to modify it, and extend it to newer channels. The first we represent by the term *inheritance*, the other we understand as *variation.* Inheritance struggles to have the plant fertilise itself with its own pollen, while the effects of variation are towards an intermixture of races or even neighbouring individuals, rather than with members of the one brood or family. May it not be possible that at some time in their past history all species of plants have been hermaphrodite? that diœcism is a later triumph of variation, its final victory in the struggle with inheritance? There are some difficulties in the way of such a theory, as there are with most of these theories; but it seems clear from this case of *Epigæa* that cultivation has not so much to do with changes as it gets credit for, and we may readily believe that independently of external circumstances there is a period of youth and a period of old age *in form* as well as *in substance,* and that we may therefore look for a continual creation of new forms by a process of vital development, just as rationally as for the continued succession of new individuals.

Monœcism in Sugula campestris.—The same observer, Mr. Thomas Meehan, has determined the practical monœcism of *Sugula campestris.* The three stigmas are produced through the apex of the flower-bud some days before the sepals open and expose the anthers. The stigmas are fertilised by the pollen of other flowers and wither away before their own flowers open.

CHEMISTRY.

Vegetable Tar as a Dye-Stuff.—M. Lefort proposes to use vegetable tar for dyeing purposes. It contains on an average about one per cent. of oxyphenic acid, which it readily gives up to water, forming thereby a liquid

which turns of a dirty green colour on the addition of a solution of perchloride of iron from the formation of oxyphenate of iron. Animal and vegetable fibres are dyed by the mixture of an ash-grey colour of great solidity. M. Lefort's process is as follows: The fibres are steeped in a solution of perchloride of iron for several hours, and when sufficiently drained, transferred to a vessel of filtered tar-water containing one of vegetable tar to ten of water heated to 60° or 80°. After several hours' maceration they are withdrawn, washed with water and afterwards with soap, to remove the aromatic and resinous principles.—*Chemical News*, Oct. 23.

The Chemical Constitution of Uric Acid.—In a note communicated to the Munich Academy of Sciences, Herr Strecker shows that uric acid may be regarded as a combination of glycocol and cyanuric acid (or 3 molecules of cyanic acid), just as hippuric acid may be regarded as a combination of benzoic acid and glycocol; for when it is heated for some time to 170° with concentrated hydrochloric acid, or, preferably, with a cold saturated solution of hydriodic acid, it yields, after removal of the acid by oxide of lead, a considerable quantity of glycocol, together with carbonic acid and ammonia.—*L'Institut*, Oct. 28.

Artificial Production of Tartaric Acid.—Along with his note on *Uric Acid*, Herr Strecker communicated to the Munich Academy another, on a new mode of forming tartaric acid. This consists in boiling for some time with dilute hydrochloric acid a mixture of glyoxal and prussic acid. The tartaric acid produced is precipitated from the solution by lactate of lime, and then obtained in the usual manner. Herr Strecker has not yet studied its action on polarised light. He considers its formation to be due to the union of glyoxal, prussic acid, and water, with the liberation of ammonia.—*L'Institut*, Oct. 28.

Phenomena of Combustion under Pressure.—M. H. Deville, in a lecture to the French Academy (Nov. 30), explains the fact established by Frankland, that the temperature of combustion of a gas is raised by making it burn under strong pressure by his theory of "dissociation." When hydrogen burns in oxygen, only half the gas ever enters into combination in the hottest part of the flame, because the tension of dissociation resists it; and this is the reason why the temperature only reaches to 2,800° instead of 6,000°, the theoretical maximum temperature. By increasing the pressure on the gas, the influence of this tension of dissociation is lessened.

Analysis of the Ashes of a Diseased Orange Tree.—The orange plantations along the south-eastern coast of Spain, and in the adjacent Balearic Isles, having been visited with a severe epidemic, the rapid progress of which rendered it of great commercial importance to the people there, Professor Bunsen, on a visit to the Balearic Isles, obtained specimens of the roots, stems, branches, and fruit of the diseased trees. Mr. T. E. Thorpe has made analyses of the ashes of these parts, and communicated his results to the Chemical Society. Comparing these results with those of analyses made some years ago by Messrs. Rowney and How of the ashes of healthy St. Michael orange trees, the comparison of the two series of results shows a great difference between them; but, then, so would a comparison of the results of analyses of the ashes of specimens of any species of plant in a healthy condition, but grown under different circumstances of soil, season, &c.

For this reason, therefore, it would be unsafe to draw any conclusion from this comparison respecting the nature of this disease, and also because the analyses were made by different operators at a long interval of time, during which analytical processes have been modified, and improved ones introduced. However, the differences pointed out by Mr. Thorpe are certainly very marked, viz., an undue proportion of lime, and a comparative lack of phosphoric acid in all parts of the unhealthy tree, with the exception of the fruit; and the concentration of potash in the fruit of the diseased tree.—*Journal of the Chemical Society* for December.

Dimethyl.—Mr. Darling has prepared this hydrocarbon, C_2H_6, in different ways, and transformed it into ethyl chloride, ethyl acetate, alcohol, aldehyde, acetic acid, &c.; confirming, by these results, Schorlemmer's conclusion, that the hydrocarbons of the above formula, from whatever source prepared, are always identical in nature.—*Journal of the Chemical Society* for November.

Products of the Oxidation of Paraffin.—By boiling paraffin for three or four days with potassic dichromate and sulphuric acid, Messrs. Gill and Mensel have obtained cerotic acid, acetic acid, and the intermediate members of the series. Somewhat similar results were obtained by boiling paraffin with dilute nitric acid; but, in addition to the acetic series of acids, succinic (already obtained by Hofstaedter) and anchoic acids were also produced.—*Journal of the Chemical Society* for November.

Compounds isomeric with the Sulphocyanic Ethers.—In a second communication to the Royal Society on this interesting class of bodies, Dr. A. W. Hofmann gives a further account of several of them, which, from their being either *homologues* or *analogues* of oil of mustard, he calls *mustard oils.* To this account he appends a theory of their constitution, and that of the isomeric sulphocyanic ethers. Selecting for illustration methylic mustard oil and its isomer methyl sulphocyanide, he shows that if in the latter body we interpret its reactions as signifying that the sulphur-atom is the link of connection between the two carbon-atoms of the compound, we must consider that it is by the nitrogen that the carbon-atoms of methylic mustard oil are chained together. The subjoined formulæ illustrate this view:—

Methylic mustard oil	Sulphocyanide of methyl
$\left.\begin{matrix} H_3C \\ SC \end{matrix}\right\} N,$	$\left.\begin{matrix} H_3C \\ NC \end{matrix}\right\} S.$

On a New Series of Chemical Reactions produced by Light.—Under the above heading, Professor Tyndall has presented to the Royal Society an account of some experiments attended with very remarkable and beautiful phenomena. By passing beams of concentrated electric light and of sunlight through tubes containing air and other gases charged with vapours of volatile liquids, chemical decompositions of undetermined nature were caused, their occurrence being manifested by the production of clouds. As the nature of the gas employed did not affect the phenomena of the production of clouds from the vapour with which it was charged, it is to be inferred that the chemical action must be in the vapour itself. The portion of the beam of white light which effects the decomposition is inferred, from the experi-

ments recorded, to be the portion absorbed. Thus a screen of chlorine was found to be most effectual in depriving the beam of the electric lamp of its power of exploding a mixture of chlorine and hydrogen. For descriptions of the symmetrical and fantastic forms and motions of the clouds of decomposed vapours, we are compelled, by their length, to refer the reader to the memoir itself, in the *Proceedings of the Royal Society*, No. 105.

On the Estimation of Phosphorus in Cast Iron.—A process for the estimation of phosphorus in cast iron is given by M. Tantin in the *Comptes-Rendus*, similar in principle to the excellent method for the estimation of sulphur. Instead of attempting to oxidise the phosphorus to the state of phosphoric acid, whereby some of it, by escaping oxidation, is not determined, he proceeds to separate it from the iron in the form of phosphoretted hydrogen, which he affirms can be completely accomplished by the action of hydrochloric acid. First passing the gas evolved through a solution of potash, to remove the sulphuretted hydrogen, he transmits it to a solution of silver nitrate, which precipitates the phosphorus as an insoluble phosphide, and converts the arsenetted hydrogen, always present, into the soluble arsenite of silver. The precipitated and washed silver phosphide is then oxidised and converted into phosphoric acid and chloride of silver by aqua regia, and the phosphorus weighed as magnesian phosphate in the usual manner.

Electro-capillary Phenomena.—M. Becquerel has added a sixth to his previous memoirs on the chemical reactions which occur between liquids communicating with each other through the capillary spaces of cracked glass, layers of fine sand, parchment-paper, and other porous septa. In this memoir (*Comptes-Rendus*, Nov. 30) he describes the formation of crystallised hydrates of chromium, aluminum, silicates, carbonates, &c. For example, by placing chromium chloride in solution on one side of a parchment-paper septum, and potassium aluminate on the other, he obtained crystals of hydrated chromium oxide and crystalline plates of hydrate of alumina. M. Becquerel believes that he has proved that the infinitely thin layer of liquid adhering to the walls of capillary spaces separating two different liquids, acts as a solid conductor to the two electricities set free during the chemical reaction of the liquids on each other in these spaces. There is thus formed an electro-chemical couple, giving rise to a current, called by M. Becquerel *electro-capillary*, to recall its origin, which has sufficient energy to reduce solutions of metals to the metallic state, and to produce, with the concurrence of other causes, a large number of combinations and decompositions. In this couple the layer of liquid adhering to the walls of the capillary cavities, which acts as the solid conductor of ordinary arrangements, has a molecular constitution differing from that of the adjacent liquid not submitted to the attractive action of these walls. M. de la Rive (in the *Bibliothèque Univ. de Genève* and *Phil. Mag.* Dec.) supposes that, instead of the liquid enclosed in the capillary space acting as a solid conductor of electricity, the observed phenomena are the effects of chemical action alone, more or less modified by the fact that the space is capillary, and, in particular, that the action can only take place on a small number of molecules at a time, and successively, instead of acting on the whole of the two solutions at once. It is very probable, says M. de la Rive, that the chemical action is modified by the so-called molecular attraction

to which capillarity is attributed; and possibly, also, that this molecular attraction is only one form of affinity (or rather, that the two forces are one), so that in the capillary spaces the liquid is not in the same conditions, physical or chemical, which it presents when it is *en masse*. Not admitting that electricity has anything to do in causing these phenomena, he prefers to distinguish them as *chemico-capillary* instead of *electro-capillary*.

A new Secondary Alcohol.—M. Lieben has obtained an alcohol isomeric with butyric alcohol by first treating ethylated chlorethyl with hydriodie acid, which gives ethylated iodethyl, and then treating this substance with moist silver hydrate. Together with the alcohol some butylene is formed. Oxidised by chromic acid the alcohol yields acetic acid, but neither butyric or isobutyric acids. It boils at 99°, and at 0° has a density of 0·827. Its constitutional formula is

$$C \begin{cases} CH_3 \\ C_2H_5 \\ H \\ OH \end{cases}$$

He has communicated his results to the Vienna Academy.

A new Synthesis of Hydrocyanic Acid.—The *Comptes-Rendus* for Dec. 7 contains a paper by M. Berthelot on the formation of hydrocyanic acid from nitrogen and acetylene gases. It is sufficient to pass a series of sparks from a Ruhmkorff's coil through a mixture of these gases in a state of purity to form the acid. But as a simultaneous but separate decomposition of the acetylene occurs, the dilution of the gases with hydrogen gas is practised in order to avoid this decomposition. Any other hydrocarbon will form prussic acid with nitrogen because of the fact that the electric spark passed through it will produce acetylene. M. Berthelot compares the formation of prussic acid from acetylene with that from cyanogen thus:—

$$C_2H_2+N_2=2CNH$$
$$C_2N_2+H_2=2CNH$$

GEOLOGY.

The Causes of the Distribution of the Iron in Variegated Strata.—The November number of the *Quarterly Journal of the Geological Society* contains Mr. George Maw's paper on the *Disposition of Iron in Variegated Strata*, read some time since before the Society. It is an elaborate memoir on the subject, and is accompanied by forty admirable chromolithographs of sections of variegated rocks. His conclusions are, first, that the great majority of cases of variegation are independent of altered chemical combinations, and more often than otherwise seem to have been induced by agencies not directly connected with chemical change. The very small proportion of them that can be accounted for by chemical change are due to the occasional conversion of the red anhydrous sesquioxide, or the lower

hydrates, into fully hydrous sesquioxide, the reduction of sesquioxide to protoxide of iron in the production of green slates, and the exceptional cases of the alteration of colour of red beds by the decomposition of bisulphide of iron. Even the agency of organic matter, in inducing chemical changes in the state of combination of the iron, will not, in most cases, account for the bleaching—the segregational motion of the colouring oxide—which is the ultimate cause of the variegation, being supplemental to the simple chemical changes of combination. Secondly, that the transferrence of the colouring oxide from one part of the stratum to another has taken place by the simple mechanical agencies of infiltration and dissolution, as well as by segregation; but that the latter, above all other agencies, has played the largest part in the variegation of ferruginous rocks.

The Quaternary Gravels of England.—From a comparison of the gravels of the Aire Valley at Bingley, of the Taff Vale between Quaker's Yard junction and Aberdeen junction, and of the Valley of the Rhonda near its junction with the Taff, and of the angles of deposition of gravel-beds concealing the escarpment of the chalk in the sections exposed at Crayford, Erith, and Salisbury, with the same conditions at Brighton and Sandgate, Mr. A. Tylor concludes: 1. That the *débris* was deposited by land-floods, and that the mode of deposition was quite distinct from that of moraines produced by the melting of ice. 2. That the character of the deposits in the valleys of the Aire, Taff, and Rhonda, proves that they were formed under similar conditions. 3. That these gravel-beds point to a Pluvial period of great intensity and duration. 4. That the ice action, of which there is evidence, was subordinate to the aqueous action. 5. That the fossiliferous quaternary deposits have been best preserved where they have been formed in cavities lying between the edge of the bank of a river, estuary, or sea, and an escarpment running parallel with it at no great distance. 6. That the immediate source of the gravels was the high land adjoining the rivers, whence they have been washed down by rain, with the assistance of lateral streams, into the lower ground, where they had come into contact with larger quantities of running water, had been mixed with rolled materials, and spread in thick beds over the bottoms and slopes of valleys or the sides of escarpments. 7. That the surface of such a deposit rarely slopes at more than from 2° to 4°, while the slope of the beds lower in the series nearer the escarpment averages 12°.—*Quart. Journ. Geol. Soc.* Nov.

Similarity between the Geological Structure of North-western Siberia and that of Russia in Europe.—The following facts have been communicated to Sir R. L. Murchison by Count A. von Keyserling: The district between the rivers Lena and Jenissei is occupied by upper Silurian rocks of the same type as those found in the region of Petchora, and by Carboniferous rocks containing seams of coal. The chief secondary deposits are of Oolitic or Liassic age, and agree with those of the Petchora region, which is the next adjacent tract on the west to the Siberian region in question. Similar rocks are found in Spitzbergen. The banks of the Jenissei are covered with post-pliocene accumulations similar to those found near Archangel. It is thus seen that the vast, slightly undulating, and to a great extent horizontal and unbroken formations, each of which occupies so wide an area in European Russia, are repeated on the eastern side of the Ural Mountains.

In this range of mountains only are to be found igneous and eruptive rocks.—*Geol. Mag.* Dec.

The Deltas of the Po, Mississipi, and Ganges.—Mr. A. Tylor has compared together the deltas of these rivers and the alluvial plains above them, and states that a parabolic curve drawn through the extremities of each river, and through one point of its course, nearly represents its longitudinal section—the greatest deviation being 30 feet in some of the largest deltas.—*Geol. Mag.* Dec.

Glaciers in Central France.—M. Martins has examined the valley of Palhères in the eastern part of the granitic *massif* of the Logère, and found evidence of the former existence of a glacier. It was a glacier of the second order, "one of those which, limited to the *cirque* which contains them, do not descend into the valley.' The crest of the vast *cirque* into which the valley of Palhères rises is capped by an elevated ridge, the summits of which, to the north and east, are formed of a white refractory granite. M. Martins found the fields and woods round the hamlet of Costeiladi within the *cirque* to be sown with innumerable erratic blocks, extending far up both the *contreforts* of the mountain. No signs of polished and striated surfaces or grooved pebbles were to be expected, as the base and *contreforts* of the valley are formed of mica-schist, too soft, of course, to streak granite or to take and retain a polish.

The Foraminifera of Kostej.—Herr Karrer has laid before the Vienna Academy his monograph on the fauna of foraminifera of Kostej, a place situated in the mountains forming the south-eastern boundary between Hungary and Transylvania. This fauna includes nearly 250 species, a great number of which are new, and particularly remarkable—such as *Dactylopora miocenica*, *Peneroplis lantei*, and numerous and beautiful Miliotides. The fauna is that of a deposit of marine origin, corresponding to the miocene stage of the Vienna and Hungary basins, and marking thus a horizon intermediate between the oldest deposits of this middle tertiary sea (Baden clay) and the littoral formations of more recent date (*calcaires leythiens*).—*L'Institut*, Dec. 2.

Ormerod's Geological Index.—A second edition is, we believe, now nearly complete, and contains the papers in the *Quarterly Journal* for 1868. Mr. Ormerod's address is Chagford, Exeter, and geologists who find errors in the Index are requested to communicate with the author of the Index.

The genus Trimerella (Billings) is the subject of a paper (translated) by Dr. Lindström in the *Geological Magazine* for October. The specimens described were found in limestone beds in the upper Silurian of Gotland. The author, having received drawings and descriptions of the specimens of Mr. Billings, found in Canada, declares that the two series of specimens are the same, those of Gotland being the more perfect. A plate accompanies Dr. Lindström's paper, in which the shells are well figured. The greatest peculiarity of the genus the author thinks consists in the presence of two siphons or tubes that penetrate the shell along the median axis of the valves or on both sides of it. These siphons, by degrees, taper off, and cease in the vicinity of the apex of the valves; their openings are of an ovate oblique form on the interior surface of the valves, and almost in the centre. An elevated shield, hiding the continuation of the siphons in its interior, is

formed by the concentric shell-layers that envelop the siphons, and, on the surface, by the mantle and other soft parts. This median elevation is smooth, having no impressions of muscular parts, and is deeply concave along the median axis. The lateral walls of both siphons are contiguous to the median axis of the valve, and continue as a straight ridge for a considerable distance down towards the inferior margin of the valve. The soft parts that secreted the concentric layers of the siphons, by degrees moved downward during the growth of the animal, filling the place they once occupied with shelly matter. Thus the apices of the siphons are generally found filled with concentric layers. Some faint longitudinal striæ are seen on the interior walls of the siphons. The concentric layers around the siphons form two stratá that are quite distinct from the rest of the shell-matter, and are embedded in it. They cannot, therefore, the author thinks, be confounded with septa, which, when they do occur in the shells, are in immediate contact with the valves, and compactly united with them. The siphons of the dorsal valve are shorter than those in the ventral valve, and often more divergent. Dr. Lindström thinks we gain the true interpretation of the nature of these siphons, if we attentively examine the interior surface of the valves in the genera *Lingula* and *Obolus*. The corresponding part of the valve of *Lingula* being occupied by two impressions of the adductors, situated on each side of a broad, faint, shield-like elevation. Though in some points he admits the relation between *Trimerella* and the *Lingulidæ*, he thinks there are many features, especially characters of the dorsal valve, which widely separate it from this family. The valves, he states, attain a thickness of fifteen millimètres, and consist in their perfect state of calcareous spar.

Chemical Geology.—Mr. David Forbes, F.R.S., has sent us a very interesting paper (reprinted from *Chemical News*, Oct. 23) on some points in Chemical Geólogy. In this Mr. Forbes deals in trenchant and forcible language and conclusive logic with the question of the constitution of the earth. Criticising M. Delaunay's late memoir before the French Academy of Sciences, he argues, with M. Delaunay, against the views of Mr. Hopkins and Archdeacon Pratt. He demonstrates that the reasonings of these writers were very correct so far as they went, but that they were based—as not a few mathematical reasonings are—on purely arbitrary premisses. Mr. Forbes's paper is one that will be read with the deepest interest, and though his conclusions, like many scientific inductions, cannot be accepted as definitively proved, they certainly appear to us much more on the side of truth than those of the opposition.

The Mineral nature of Eozoon.—Messrs. King and Rowney, persisting in their views on this subject, sent in a memoir on the "so-called Eozoonal rock" to the Geological Society on Wednesday Dec. 23.

MECHANICAL SCIENCE.

Radiation from Steam Boilers.—Some interesting experiments have been made by Messrs. Fox, Head & Co, at Middlesborough-on-Tees, on the effect of a non-conducting coating of cement in reducing the radiation of heat from the surface of steam boilers. The boiler experimented on had a superficial exposed area of 280 square feet. In the first experiment with the boiler uncovered, 14·8 cubic feet of water were evaporated per hour; in the second experiment, the boiler having been covered with non-conducting cement, the evaporation was at the rate of 20·4 cubic feet per hour. The coal used, and the circumstances under which the water was evaporated, were exactly the same in the two cases.

Liquid Fuel on Shipboard.—Messrs. Dorsett and Blythe, of the Patent Fuel Company's Works, have fitted on board the Retriever, a screw steamship of 500 tons burden, an apparatus for the generation of steam by the combustion of creosote and other liquid hydrocarbons. The creosote is first evaporated in two small vertical boilers, or generators, and the vapour is then conducted to the furnaces of the steam boilers, in which it is burnt. At starting, an ordinary fire is kindled in the generators, and when the pressure of the creosote vapour rises to about 20 lbs. per square inch, a portion of the vapour is conducted into the firebox of the generators, and supplies all the heat subsequently needed for the evaporation of the liquid fuel. The Retriever has been tried on the Thames with perfect success, the apparatus working without a hitch, and the combustion being apparently perfect. It remains to be seen whether any practical difficulties in the application of the system will be found on more extended trial, and whether the economical results are such as to justify its adoption.

Apparatus for exhibiting the Laws of Wave Motion.—An extremely interesting paper on the laws of wave motion, and on an apparatus for illustrating them, by Professor C. S. Lyman, will be found in *Engineering*, Nov. 6. The apparatus exhibits to the eye not merely the motions of the surface contour of a wave, but also the motions that are at the same time taking place below the surface, in the whole mass of liquid affected.

Solar Engine.—Captain Ericsson has been making experiments on the utilisation of solar heat in the production of mechanical force. According to a notice transmitted by him to *Engineering* (Nov. 27), his experiments, in which the radiant heat of sunbeams of from 650 to 5180 square inches in section was concentrated on a small surface, do not altogether confirm the results obtained by Pouillet and Herschel with the small instruments hitherto employed for measuring the quantity of radiant solar heat. Further experiments are to be prosecuted, and in the mean time he states that several experimental engines have actually been constructed, actuated by the sun's radiant heat. In some of these engines, atmospheric air heated to 480° by concentrating the sun's rays is used; in others, steam generated in the same way. A regular and continuous rate of 300 revolutions per minute has been attained by some of these engines.

Intercommunication in Railway Trains.—It has now been made imperative on railway managers to provide means of communication between passengers

and guards in all trains running greater distances than twenty miles without stopping. With a view of determining on the best means of complying with the requirements of the Board of Trade, a meeting of engineers and others interested in the matter has been held at York, and a series of experiments were carried out on the various systems proposed. Amongst these systems we may mention that of Mr. Ramsbottom, in which a whipcord line is extended from the engine to the rear van, attached on the former to a whistle and at the latter kept in tension by a weight. If the rear guard pays out line, or if a passenger cuts the cord, the whistle sounds, being opened by a spring as soon as the tension on the cord is diminished. Mr. Harrison has a rope system in which the whistle is opened by a pull on the cord, the lengths of rope being permanently attached to the carriages, and joined between them by hooks and eyes; when the rope is pulled a semaphore is released and fixes itself so as to indicate the point from which the signal has been given. Various electrical systems were also tried. More recently, Mr. Latimer Clarke has produced a pneumatic system, on which experiments have been made at Sevenoaks. This consists of a heavy gong on the engine, and a smaller one in the guard's van. Both gongs are struck by hammers actuated by the train itself. The gear which actuates the hammers is connected with vacuum cylinders connected with a pipe running the whole length of the train, from which the air is continuously exhausted by a pump on the tender. The pipe is in communication with plugs in the carriages. Any passenger pulling out one of these plugs destroys the vacuum in the pipe, the mechanism of the gongs falls into gear, and the gongs are sounded. This system of Mr. Clarke answered its purpose admirably in the experimental trial, and certainly appears to possess many merits.

MEDICAL SCIENCE.

Bacteria in Glanders and Farcy.—MM. Christot and Kiener have found bacteria in the blood of glandered horses, and very abundantly and of large size in the spleen and in the pus. Along with this presence of bacteria there was usually leucocythæmia.—*Comptes-Rendus*, Nov. 23.

Re-establishment of Sensibility after Resection of Nerves.—A memoir by MM. Arloing and Tripier was read before the French Academy, Nov. 23, on the effects of resection of certain nervous trunks. Clinical facts have several times shown that after wounds which have altered or destroyed a portion of a nerve, sensibility returns in the integuments to which the nerve is distributed. MM. Arloing and Tripier made nervous resections in dogs, and saw sensibility reappear after a certain time in the integuments to which the branches of the nerve were distributed, and in the peripherical end of the nerve itself.

The Use of Ergotin after Operations.—M. Bonjean states that the mortality from amputations has in the Hôpital de St. André in Bordeaux been greatly reduced by administering ergotin, 30 to 50 grains per diem, for a fortnight, beginning its use immediately after the operation. The result has been the absence, or at least the marked diminution, of suppuration. It appeared to

act nearly as well when applied to the wounds themselves.—*Comptes-Rendus* for Nov. 30.

Creatine in Milk.—In a note to the French Academy, M. Commaille announces that he has obtained creatine from putrefied whey. This is, without doubt, derived from creatine by dehydration, so that, according to M. Commaille, the latter substance must be a constituent of new milk. Its presence has not been hitherto made out on account of the large quantity of other matters with which it is united in new milk. M. Commaille finds in the presence of creatine a new analogy between milk, blood, and meat, and doubts whether creatine is an excrementitious matter.

Influence of Veratrum on the Heart.—M. Oulmont, who has been continuing his experiments on the physiological action of *Veratrum viride* and on its therapeutical effects, recently read his second paper on these subjects before the French Academy of Medicine. He finds that the resinous extract in doses of about a centigramme every hour lessens and steadies the pulse, and considerably diminishes the temperature. He has tried it in pleuritis, pneumonia, and typhoid fever, and while it gave bad results in the first and third, it proved of immense service in the second.

Muriate of Ammonia as a cure for Neuralgia.—Many of our non-professional readers have no doubt heard of sal-ammoniac as a remedy for certain forms of toothache, and perhaps have tried it with advantage. There has hitherto been a great dearth of scientific information on the action of this remedy. We therefore direct attention to an able paper on "Muriate of Ammonia in certain nervous disorders," which has been written by Dr. F. E. Anstie of Westminster Hospital. Dr. Anstie shows that while the muriate is surprisingly beneficial in some cases it is inert in others. But he recommends that it be given a fair trial. Our own observations fully accord with Dr. Anstie's published views.—See *The Practitioner* for December.

Vibriones developed after administration of Cyclamine.—In the third number of the *Archives de Physiologie*, M. Vulpian describes some experiments made on frogs by injecting the active principle of *Cyclamen Europæum* beneath the skin. After death the blood is found loaded with vibriones, and these in some cases are seen within the substance of the corpuscles themselves.

Methyl- and Ethyl-Strychnia.—MM. Jolyet and Cahours have, in a recent number of the *Comptes-Rendus* (November), at last recognised the splendid inquiries of Messrs. Fraser and Crum Brown. But singularly enough they express an opinion to the effect that this field of research—the influence of substitution on the physiological effects of alkaloids—is especially their own. We don't agree with them.

Devonshire as a health-resort.—As one of the chief peculiarities of the Devonshire climate is supposed to be its moisture, we would refer those of our readers who are anxious to obtain some scientific knowledge of the hygrometric facts to a valuable paper on the rainfall of Devonshire, by Mr. W. Pengelly, F.R.S., in the *Transactions of the Devonshire Association for the Advancement of Science* for 1868. After giving numerous carefully drawn up tables, the author says: "In brief, Devonshire stands first among the English and Welsh counties, and in descending order thirteenth

in its mean annual fall, ninth in the average number of wet days, and twelfth in its mean daily fall. Compared with the entire country, its rainfall is 23 per cent.; its wet days 6 per cent., and its daily fall 15 per cent. above the average.

Liebig's Extract of Meat.—Baron Liebig has forwarded to us some samples of his improved "extract," prepared by the Fray-Bentos Company. These we have not yet satisfactorily examined, but there is reason to believe that this extract is in point of flavour a great improvement on the previous preparation. We may, in passing, call attention to the fact, that the experiments recently made by Herr Kemmerich, and held by some to prove that the extract is in large doses injurious, have been of so inexact a character, and made in such a peculiar manner, that they must be regarded as inconclusive. The *Practitioner* was the first journal to call attention to them in this country, and it by no means concurred in Kemmerich's expressed opinions, but, on the contrary, stated that they required confirmation. Journals like *Once a Week* and others, which make a sort of ill-digested meal of the thoroughly scientific periodicals, copied part of the paragraph in the *Practitioner*, but not all, and occasioned a good deal of mischief, through leading the public to believe that the extract of meat is poison. As the first journal which drew attention to the *Extractum carnis* in this country, we may be allowed to express our protest against crude experiments and hasty conclusions like those of Dr. Kemmerich. For a complete *exposée* of Kemmerich's opinions, our readers should refer to a letter by Baron Liebig, which appeared recently in the *Lancet* (November).

Spontaneous generation.—In reference to this questioned phenomenon, a paper of M. Trécul's has lately been laid before the French Academy. The author's conclusions relate especially to the formation of yeast in beer, and are as follow: 1. Yeast cells may be formed in the must of beer without spores being previously sown. 2. Cells of the same form as those of yeast, but with different contents, arise spontaneously in plain solution of sugar, or to which a little tartrate of ammonia has been added, and these cells are capable of producing fermentation in certain liquids under favourable conditions. 3. The cells thus formed produce *Penicillium*, like the cells of yeast. 4. On the other hand, the spores of *Penicillium* are capable of being transformed into yeast. Finally, he states that spontaneous generation is the great obstacle to satisfactory observations, because it mixes its own products with those placed by the observer for experiment.—Vide *L'Institut*, December 23, 1868.

The Physiological Action of Cyanogen Gas.—Herr Dr. Laschkewitsch, from his experiments with cyanogen on blood, and on frogs and other cold-blooded animals, and birds, guineapigs, &c., draws the following conclusions: 1. Cyanogen does not enter into chemical combination with hæmaglobin, although it changes it as it does other albuminoid bodies. 2. The ciliary motions of the epithelium are increased by a weak solution of cyanogen, and arrested by a concentrated solution, cyanogen in this respect agreeing with ammonia. 3. The strong tetanic cramps are caused by the action of the cyanogen on the central nervous system. 4. The stoppage of the heart arises from irritation of the vagus nerves. 5. On the peripheral nerves cyanogen acts as a powerful irritant. 6. The blood

of animals poisoned with cyanogen shows clearly in its spectrum both the lines of oxyhæmaglobin.—*Archiv f. Anat. u. Phys.*, November.

The Conduction of Sensory Impressions.—In an article in the December number of the *Archives de Physiologie*, Dr. Brown-Séquard states that the conductors of sensory impressions do not cross in the base of the brain but reach it already crossed, and that, therefore, their intercrossing must take place in the spinal marrow.

Experiments on Transfusion.—At a recent meeting of the Vienna Academy of Sciences, Herr Mittler read a paper detailing his numerous experiments on this important problem. He finds that transfusion is a much less dangerous operation than has been supposed by medical men generally. He repeated the old experiment of introducing birds' blood into the vessels of mammals, and found, as did previous physiologists, that the oval corpuscles may be distinguished for several days, but that ultimately they disappear. His results may be summed up as follows: 1. Blood directly transfused from one vessel to another does not provoke coagulation in the circulation of the animal submitted to the operation, whether it be allied or not to the one from which it receives the blood. 2. Blood directly transfused continues its functions within the vascular system of a kindred animal much more completely than blood injected after having been deprived of its fibrin. 3. Blood directly transfused from an animal not allied to it is generally borne by an animal better and in markedly larger quantity than blood defibrinated previous to injection. 4. The blood-globules of mammifers can be seen for two or three days after in the blood of birds submitted to injection. 5. The narrowest capillaries of mammalian animals present no obstacle to the passage of the large elliptical corpuscles of birds. 6. Suppositions still strongly believed in, as to the toxic action of foreign blood are either inexact or erroneous: the coagulation of this blood, and the existence of the carbonic acid which it contains have no influence on the symptoms caused by it. 7. Blood injected or transfused is some time after the operation secreted in many cases by the kidneys. Sometimes effusions of blood are observed in the parenchyma of the wounds caused by the operation. 8. It may safely be admitted that blood corpuscles thus secreted first lose their colouring matter and then perish like those placed without the vascular system. 9. The experiments in question have not definitively cleared up whether the transfused blood loses its physiological powers immediately on being received into a foreign vascular system or whether these powers continue to exist for a certain period.—*L'Institut*, Nov. 18.

METALLURGY, MINERALOGY, AND MINING.

On the Application of Chlorine Gas to the Toughening and Refining of Gold.—A paper on this subject by Mr. Francis Bowyer Miller, assayer in the Sydney branch of the Royal Mint, was read at the Chemical Society in November, which appears to be of great practical importance. If Mr. Miller's process proves as successful in other hands as in his, its simplicity and economy will ensure its extensive employment in this country and elsewhere

It consists in passing chlorine gas into the molten gold by means of a clay pipe dipping down to the bottom of the crucible containing it. No difficulty is experienced from the projection of globules of gold, as might perhaps be expected would be the case. The greater part of the chlorine seems to be absorbed at once, and no violent ebullition consequently takes place. The chlorine converts the silver into chloride, which floats in the liquid state on the gold. With the apparatus used by Mr. Miller, about eight ounces of silver were thus separated as chloride from gold alloyed with it, and at nearly a uniform rate, whether the gold contained much silver or little. To obviate the loss of the fused chloride of silver by infiltration into the substance of the clay pot, the latter is to be prepared by dipping it into a hot saturated solution of borax in water so as to be thoroughly impregnated therewith, and then drying it. No absorption of chloride then occurs with it. The volatilization of all but a very minute proportion of chloride of silver is prevented by the use of borax to form a fused layer over the chloride. The time required for the operation to bring the gold to a fineness of, say, 993 parts in 1000 is only a few hours, while the *apparent* loss of gold is very little more than what is known to occur in ordinary gold melting, being $2\frac{9}{10}$ parts in 10,000, whereas in ordinary mint melting the *apparent* waste is about two parts in 10,000. "By *apparent loss* is meant the loss at the end of an operation, without taking into account the amount recoverable from 'sweep,' &c." The slab of argentic chloride is reduced to the metallic state by placing it between two flat pieces of wrought iron, and immersion of the whole in sulphuric-acid water. But previous to this, as the cake contains a little gold (apparently in chemical combination), Mr. Miller recommends its refusion and treatment with a little carbonate of potash, which separates the gold and a little silver, leaving the chloride free from gold. Lastly, as regards the quantity of chlorine necessary, about twice the theoretical quantity only is required, half of it passing unused into the chimney.—*Journal of the Chemical Society* for December.

The Different Colours of Labradorite.—A microscopical examination of a number of specimens of this mineral in the collection of the École Polytechnique des Pays-Bas, all from the Labrador coast, has enabled M. Vogelsang to give an explanation of the splendid play of colours often exhibited by it. In the coloration of labradorite its more or less crystalline structure plays an essential part, for the coloured specimens show usually a better cleavage than the colourless ones. The bright blue reflected by some specimens depends upon a certain crystalline state of the mineral, and is a phenomenon of polarisation produced by the passage of rays refracted by one lamina into another lamina, the planes of vibration of which do not coincide with those of the first, the result being a difference of phase and an interference of the luminous rays on reflection, just as with the ordinary colours of polarisation. The golden-yellow colours proceed from a total reflection from interposed microlites which consist of magnetic oxide of iron, or else of diallage; the red colour results from the reddish colouring of small lamellæ of diallage; the association of these colours with the blueish reflection accounts for the green and violet play of colours; lastly, the coloured metallic reflection from laminæ of diallage gives rise to the effects of coloured aventurine.—*Archives néerlandaises des Sciences exactes et naturelles.*

Titaniferous Magnetites.—In an article in the *Chemical News* for December 11th, Mr. David Forbes says that the only objection to the use of titaniferous ores for smelting is that they are found to be more and more refractory in the blast-furnace in proportion as they contain a greater percentage of titanic acid. If much titanium is present, they require so much larger an amount of charcoal to smelt them as not to render their employment profitable in a country where other ores free from titanium can be obtained at a reasonable rate. Employing a mixture of stamped quartz and lime as a flux Mr. Forbes obtained very satisfactory results; and when the amount of titanium in the ore did not exceed 8 per cent., or was reduced to this percentage by admixture of other ores of iron free from titanic acid, no difficulty was experienced in working this ore cleanly and profitably. The cast iron produced contained no phosphorus, only a trace of sulphur, and afforded 0·05 per cent. titanic acid, equal to 0·03 per cent. titanium, which Mr. Forbes imagines was rather mechanically intermixed than chemically combined with the iron. The cast iron, however, possessed a peculiar fracture, not easily described, but easily distinguished by the furnace-men, who could at once recognise the pig from these ores even after it had been remelted in the cupola.

Assay of Silver in the Wet way.—It is well known to assayers that a difficulty in the application of Gay-Lussac's process for assaying silver has to be got over, arising from the fact that in adding to the silver solution the standard solution of salt, a point is reached when the liquid will give a precipitate by the addition of either silver solution or chloride of sodium. M. Stas points out in a letter to M. Dumas that this is entirely avoided by substituting bromide for the chloride.—*Comptes-Rendus*, Nov. 30th.

Conversion of Pig Iron into Steel.—The *Mining Journal* speaks very highly of the working of Mr. Heaton's patent at the Works close to the Langley Mills Station of the Midland Railway. The process by which the iron is converted is by the use of nitrate of soda, by which the whole of the phosphorus is evolved. The pig iron is put into an ordinary furnace for about three-quarters of an hour, and then is run into the converter, and in the course of four or five minutes the converting process has been completed. The process for melting the pig iron is an ordinary one, there being an inclined tramway leading to a platform, and thence to the charge-hole. There are tuyères for supplying air to the cupola, without any blowing engine. The steel is of uniform character, and appears to be capable of being adapted for almost every purpose for which steel is generally used. The cost of the plant necessary for the Heaton process does not exceed 600*l.*

METEOROLOGY.

The Carbonaceous Matter of Meteorites.—By applying to the carbonaceous matter found in some meteorites his method of hydrogenating organic carbon compounds so as to convert them into their corresponding carburetted hydrogens, M. Berthelot has obtained carbo-hydrogens, both liquid and gaseous, which are similar to those of petroleums. A new ana-

logy is thus shown between the carbonaceous matter of meteorites and that of organic origin on the surface of the globe.

The Errors in the Measurement of the Temperature of the Solar Radiation by the Black-Bulb Thermometer.—In consequence of the diathermancy of black glass, of which black-bulb thermometers are usually constructed, Mr. R. L. J. Ellery has compared the indications of one of the ordinary black-bulb thermometers with another thermometer with its bulb coated with lamp-black. These thermometers read the same in the shade, and as ordinary thermometers were accurately intercomparable. In the sun, the coated bulb always attained a higher temperature than the other, and the difference was found to vary with the temperature—the greater the temperature the greater the difference. For example, when the coated bulb thermometer indicated 77·3°, the black-glass bulb one indicated 70°; when the former indicated 155·7° the latter marked only 140°. Part of this difference Mr. Ellery points out must be due to the polished surface of the black glass bulb reflecting many rays, which are absorbed by the dead surface of the blackened bulb.—*Trans. of Roy. Soc. of Victoria*, pt. i. vol. ix.

PHOTOGRAPHY.

Use of Printing Press to Photographers.—In the *Photographic News* for December 11, Mr. Thomas Gulliver recommends the use of the printing press to photographers for the purpose of printing their own circulars.

Removal of Silver Stains from the Hands.—The same journal gives the following receipt as better than that recently recommended by Mr. Carey Lea: "Put half a pound of glauber salts, quarter of a pound of chloride of lime (the sanitary disinfectant), and 8 ounces of water, into a small wide-mouthed bottle, and, when required for use, pour some of the thick sediment into a saucer, and rub it well over the hands with pumice-stone or a nail brush, and it will clean the fingers quite equal to cyanide, but without any danger. This will do to use over again until exhausted, and should be kept corked up. The disagreeable smell may be entirely avoided by the liberal use of lemon juice, which not only removes the smell, but whitens the hands. Rotten ones may be used, and answer well."

Carrier's Sensitive Albumenized Paper has thus been reported on by one of our contemporaries, whose editor had recently received a sample from Mr. Solomon. The specimen had been prepared nearly twelve months: "We found it perfectly unchanged in all respects, without a trace of discoloration; and printed and treated throughout side by side with that just received from Mr. Solomon, there was no difference in result, both being perfectly clean and pure. The unchangeable character of this sensitive paper is thus proved beyond a question. Its qualities remain just the same as we before described them. It gives an exquisitely delicate and soft print, but lacks a little vigour, unless a negative with full contrast be employed. A special toning bath is recommended, which we before tried with success; this time we used an old sulphocyanide of gold bath, made some months ago, with perfectly good results."

Lamps for Photography.—Two forms of lamp have been recently devised which deserve notice. One is the ingenious Electric Lamp of Mr. Browning, and the other the Magnesium Lamp of Mr. Solomon. Mr. Browning's lamp is so contrived that the charcoal points are always kept together by means of an electro-magnet and armature. The upper bar containing the upper charcoal point, is the one which is clamped by the magnet when the current travels through it. This lamp is especially suitable for lanterns, giving a good 9 feet disc with a Grove's battery of about 8 cells. Mr. Solomon's Magnesium Lamp has, as usual, clockwork for uncoiling the ribbon off the bobbin. The ribbon is about 50 yards long, and will give a steady light for about two hours.

Landscape Photography in Cloudy Weather.—Mr. M. Whiting, Jun., sends the following note to our interesting contemporary, *The British Journal of Photography*, No. 449: "When taking distant views and a variety of scenery on a dry plate (especially in Scotland), on a cloudy day, where a part of the view may contain dark woods or other foliage, which, with an ordinary exposure would hardly come out sufficiently distinct, great assistance can be secured by the following plan: Suppose the whole exposure will require four minutes: first give two or three minutes with the average light, and, for the remainder, only uncap the lens when that part of the view you wish more fully to expose is lit up by the sun and the other part is in shadow. This is far more easy to do than it appears to be."

A new Mount for Photographs has been brought out by Mr. Fox, and is favourably spoken of. The new mount, instead of having a tint for immediate contact with the picture, surrounded by a broad white margin, is printed with a broad tint, which constitutes the margin, with a space of plain white in the centre, leaving a margin of white to come into contact with the picture itself. This effect with many pictures is very pleasing. For instance, in landscapes where the sky has printed through to a delicate tint, the print, if mounted on an India tint, would appear to have a white sky; mounted, however, in contact with the white portion of a board having a tint beyond, the atmospheric tint of the sky receives its full value, and the picture becomes effective. The same is true of vignetted portraits in which the background softens into a grey tint instead of into white, and in a number of other cases the new style will produce a more pleasing result than any yet devised.

Cheap Magnesium.—A writer in the *Builder* says: "There is now a fair prospect of a reduction in the price of magnesium through some recent improvements in its manufacture, and it is probable that in the course of next year we shall see the metal retailed at or under one shilling per ounce."

Photographic Paper.—A contemporary states that a prize of 2,000 fr. has been offered in France for the production of the best photographic paper. The prize will be awarded in 1869.—*Photo. News*, Dec. 15.

Treating Negative Baths.—Mr. M. Carey Lea gives the following results obtained by Dr. Jacobsen when treating disordered negative baths with permanganate of potash: "The first bath tried was an ordinary negative bath which had ceased to work clean. A solution of permanganate was dropped carefully in, so long as its deep red colour was destroyed by stirring up the bath. As soon as a drop of permanganate left a coloration which did not

disappear the bath was filtered and gave clean pictures. The second was a bath which had been used with Harnecker's collodion, and was choked up with organic matter producing fog. With this bath, four or five times as much permanganate was required as the other. When enough had been added the bath was filtered, and, *at first*, gave clear pictures, but, after standing a little, fogged. On being acidulated with dilute nitric acid it worked perfectly. The explanation of this last lies in the tendency of the permanganate to render a bath alkaline; therefore the proper mode of treatment is, if much permanganate has been added, to acidulate the bath. If but little has been needed the bath may be tried, and no acid need be added unless a tendency to veil show itself."—See "Spirit of the American Journals" in *British Journal of Photography*, Dec. 18.

PHYSICS.

A New Constant Battery.—This battery, intended rather as an "intensity" than a "quantity" battery, has been devised by Messrs. De la Rue and Müller. Having experimented with it since its construction was first made known in February, and more especially tested its electro-motive force, the inventors have recently given a detailed account of it to the Chemical Society. The battery is compact and always ready for use; no porous cell is needed, and, with the electrodes disconnected, the elements may be left immersed for several weeks, as the electro-positive metal is then scarcely acted on in consequence of the electrolyte being solid and very nearly insoluble. The positive metal is, as usual, zinc. It consists of Belgian zinc wire (English being objectionable from its impurity) $2\frac{5}{8}$ inches long and 0·2 inch thick. The negative element is pure silver in the form of wire 0·03 inch thick; and round this is cast the electrolyte, a cylinder of chloride of silver 0·22 inch in diameter. The silver wire projects about 0·2 inch beyond the bottom end of the chloride of silver, and about $1\frac{1}{2}$ inch above the top of it, so as to permit of its connection with the zinc of the next pair of elements. The cells are conveniently formed out of 1-ounce vials by cutting off the necks with a diamond or an ignited splint coal. The zinc and chloride of silver rods pass through, and are supported by a lath of varnished mahogany. The ends are pierced by two holes large enough to allow of it sliding freely up and down two vertical supporting rods of glass. Upon these glass supports it is retained at any desired height by vulcanised caoutchouc collars; these grip the glass rods with adequate firmness to support the mahogany bar, but at the same time permit of its being moved up and down with sufficient freedom to immerse the elements partially or wholly or to raise them entirely out of the liquid. The raising is conveniently performed by placing the two forefingers of each hand under the collars and pressing the thumbs on the top of the glass rods; the lowering can be effected by pressing down the two ends of the bar. The glass rods should not be varnished on that portion over which the vulcanised collars have to slide, as the varnish causes too much friction; below this point they may be varnished with advantage. They are cemented into a base of varnished mahogany, in which

is made a series of recesses to fit the cells and keep them in their places. This base rests on feet of vulcanite to increase the insulation. The zincs pass through holes in the bar and are kept in position by vulcanised collars. Above these collars another on each zinc serves as a clip for making connection with the silver wires, which is done by passing the wire between the zinc and the collar. The silver wires pass through holes pierced in pieces of gutta-percha or ebonite, fitted into the mahogany bar, the holes being only just large enough to permit of the wire being drawn through them. The zincs are better amalgamated, but need not be so. The cells are charged with a solution of salt in distilled water, 25 grammes to the litre. When the chlorine is more or less completely exhausted by the reduction of the cylinders through their entire thickness, the resulting rods of spongy silver can be renewed and reconverted into chloride with scarcely any loss of silver, so that the cost of the renewal of the battery is chiefly one of labour. The inventors find that their battery has about the same electro-motive force as Daniel's battery. They also give experiments showing the constancy of the battery.

The Relation of Mechanical Strain of Iron to Magneto-electric Induction.—Mr. G. Gore has established, by means of an apparatus he describes in the *Philosophical Magazine* for December, that a magnetised soft iron wire during the act of being stretched (either with temporary or permanent elongation) *increases* in magnetism and produces in a coil of insulated copper wire surrounding it, a current of electricity in a contrary direction to that of the hands of a watch when we are looking towards its south pole.

A Molecular Change in Tin produced by Cold.—At St. Petersburg last winter, according to Herr Fritsche, tin exposed to a temperature of 40° below zero, was converted into a semicrystalline mass, containing cavities like basalt. Some of these cavities in masses of 25 or 30 kilos. of tin had a volume of 100 cubic centimeters. According to M. Dumas facts of this kind were not new in Russia; in one case the organ pipes in a church were so altered by the cold as to be no longer sonorous. The fracture of axles by cold is perhaps a fact of the same nature.—*Comptes-Rendus*, Nov. 30.

A New Method of measuring the Intensity of Light.—A simple instrument for this purpose has been devised by Mr. Roger Wright, and has been recently described in the *Proceedings of the Royal Society*, for measuring approximately the intensity of total daylight for comparative purposes. It consists of a solid rod of metal standing perpendicularly on a heavy base. The top of the cylinder is painted white with a black spot in the centre. A hollow tube blackened inside is made to fit exactly and slide over this rod. The rod is marked with a scale, beginning with zero at the base. To use the instrument, the tube is pushed over the rod down to the zero-point; it is then drawn slowly up, the observer looking steadily at the black spot, and when the spot vanishes in the gloom, the point is read off on the graduated scale. This point will, of course, vary with the intensity of the light, and thus a measure of the intensity is obtained.

A New Differential Refractor for Polarised Light.—M. Jamin has described to the French Academy an instrument adapted to all the purposes of his differential refractor for ordinary light, by which polarised light may be employed instead.

Origin of the Heat developed in the Cells of a Battery.—According to M. Favre, the heat which is not found in the galvanic circuit, but confined within the cell, can only be traced to the intervention of the following circumstances, alone or united: 1st, the condensation of hydrogen on the platinum (of a Smee's couple), which becomes an obstacle to the transmission of the current; 2nd, the local action due to the passage of hydrogen from the *nascent* to the *ordinary* state; 3rd, the action, also local, due to the conversion into sulphate of the zinc deposited on the platinum of the couples by the electrolysis of the sulphate of zinc constantly increasing in the liquid in the cells.—*Comptes-Rendus*, Nov. 23.

The Illuminating Power of Flame.—M. Deville cannot agree with Dr. Frankland in considering the degree of luminosity of a flame to be dependent upon the density of the gases forming it. The illuminating power of a flame entirely gaseous is a specific property connected with the production of the spectral lines furnished by the matters it contains; and is as inexplicable as the specific properties of the bodies themselves, such as density, colour, &c. For a flame to be luminous it is only necessary for it to be white, that is, for its spectrum to be extended. When the temperature is raised all metallic spectra acquire new lines, take all the different colours which together form white light, and consequently acquire a greater illuminating power.—*Comptes-Rendus*, Nov. 30.

Why Soap-Bubbles can be blown, and not Water-Bubbles.—Viscosity, as ordinarily understood, is quite insufficient by itself to explain the bubble-forming capability of certain liquids. According to M. Plateau (*Comptes-Rendus*), "the superficial layer of liquids has a viscosity peculiar to it, and independent of the viscosity of the interior of the mass; in certain liquids this superficial viscosity is stronger than the interior viscosity, and often very much so; in other liquids it is, on the contrary, weaker than the interior viscosity, and often also very much so;" and he is led to conclude from his experiments, that for a liquid to be capable of being spread out in sheets at once large and persistent, and consequently for it to permit of being blown into bubbles, in the first place its superficial viscosity must be great; but besides this, its tension must be relatively feeble; in other words, the ratio of its superficial viscosity to its tension must be sufficiently high.

Researches on Calorific Spectra.—Further experiments by M. Desains serve to establish the statement he had previously made to the French Academy, that if in perfectly pure spectra pencils are isolated, composed of rays whose deviations through the same prism are almost identical with each other, they will be found to be very unequally transmissible through the same absorbent medium when they proceed from different sources (*Comptes-Rendus*, Nov. 30). *L'Institut* remarks that this discovery of M. Desains gives the *coup de grâce* to the error firmly rooted in the minds of physicists, that a colour or a radiation is perfectly determined either by its wave-length or by the duration of its vibration.

Similitude of Hydraulic Trajectories.—According to M. Brettes, hydraulic trajectories appear to be similar when the initial velocities of the water coming out of similar orifices make the same angle with the horizon, and are proportional to the square roots of the diameters of these orifices if they

are circular, or of their homologous diameters if they have any other form. —*Comptes-Rendus*, Nov. 2 and 30.

Mode of Conduction of Heat by Bodies.—M. Magnus has read an important paper before the Berlin Academy of Sciences, furnishing the proof of the proposition already asserted by him, that heat is propagated in bodies by transverse vibrations like light, or, at the very least, that transverse vibrations play a most important part in the transmission. M. Magnus had shown in a previous memoir that heat radiating at an angle from a red-hot and polished plate of platinum proceeds both from its surface and from its interior, this being a consequence of the polarisation of the heat which radiates from this surface. The plane of polarisation has the same situation as that of light refracted at a certain angle. It must therefore be admitted that a portion at least of the rays is refracted at the surface; but for this refraction to be possible the heat must come from the interior of the platinum. This polarisation is effected according to the same laws as those of light, and therefore the interior propagation must be performed, like that of light, by transverse oscillations. M. Magnus had asserted his proposition on the grounds that the motion called heat cannot be double, and that its propagation when made through air, through a vacuum, or through any other diathermanous substance by means of transverse oscillations, must be of the same kind as in the interior of athermanous bodies which we call conductors. But this conclusion was not a certain one; the only point of it made out was that heat was polarisable. But if it is proved that heat radiating at an angle at any temperature whatever, and therefore at a very low one, is also polarised in part, it will be established, even for opaque bodies, that the heat radiated by them proceeds partly from their interior, and is propagated in them by transverse oscillations. It would then be proved, M. Magnus believes, that the conductibility of heat, or its propagation in athermanous bodies, rests on transverse oscillations. In his present communication M. Magnus has furnished this part of the proof required, by experiments which establish that bodies heated to 100° radiate polarised heat.—*L'Institut*, Nov. 18.

A new Exciting Liquid for Galvanic Batteries.—A French chemist suggests the following compound liquid for electro-galvanic batteries: Twenty parts of protosulphate of iron in thirty-six parts of water, seven parts of sulphuric acid, and one part of nitric acid. He declares this to be the most powerful and exciting liquid, attacking iron, zinc, and other metals, without any evolution of hydrogen or binoxide of nitrogen.—*New York Medical Record*, Dec. 1.

A new way of Detecting the Discordance of Diapasons.—A means of discovering a want of accordance between two diapasons has been pointed out by M. Lissajous, in a note to the French Academy. They are to be made to vibrate, and then put in connexion with a bath of mercury. When they are in accordance the surface of the mercury remains perfectly calm. If there is discord between them waves are produced on the surface directed towards that instrument of which the vibrations are the less in number.—*L'Institut*, Dec. 16.

ZOOLOGY AND COMPARATIVE ANATOMY.

The Fresh-water Crustacea of Belgium.—M. F. Plateau has given the following abstract (*Comptes-Rendus*, Nov. 23) of his memoir on the genera of *Gammarus*, *Lynceus*, and *Cypris*. *Gammarus puteanus* (Koch) is a species and not a variety; its rudimentary eyes perceive light. The species of *Lynceus* have maxillæ for trituration, furnished with a crown of conical tubercles; their digestive tube, instead of being simple like that of *Daphnia pulex*, is distinctly divided into œsophagus, stomach, small and large intestines; the other members than the antennæ affect three different forms: natatory appendages (first pair), appendages for the production of the aqueous current (second and third pairs), appendages exclusively respiratory (fourth and fifth pairs). The male reproductive apparatus is lodged in a pouch borne by the last joint but one of the tail; it is formed of two sacciform testes and two deferent canals, opening at the base of the caudal plate. The females, like the Daphniæ, carry well-marked *ephippiums*, but they are composed of two distinct capsules. Opposed to what Rathke has said of the Daphniæ, the eye in the embryo is a single pigmentary mass, which *afterwards* divides into two. M. Plateau has confirmed by new observations the researches of Herr Zenker, who discovered the males of *Cypris*, and thus upset the old theory of the hermaphrodism of these animals. He shows, further, that the seat of formation of the spermatophores in the male Cypris is not the deferent canal, but the axial tube of the mucous gland; that the form of the valves in the young is generally at variance with that which they assume in the adult; lastly, he shows that Cypris, although resisting the privation of water for a certain time, does not manifest this property in a higher degree than most other small aquatic animals.

The Scolex of Phyllobothrium in a Dolphin.—M. E. van Beneden has found in the body of a male *Delphinum delphis* the Scolex of Phyllobothrium, a cestoid living in the angel-fish, and several sharks. Here, then, remarks M. van Beneden, is a cestoid which begins its evolution in a cetaceous, and completes it in a plagiostomous fish.

The Animal "Cell" not essentially different in Function from the Vegetable.—In a paper read before the Association of German Naturalists, at its last session in Frankfort, on the *Physics of the Cell*, Herr Wundt stated as follows:—It used to be thought that the vegetable cell had to form organic matter, and that the animal cell had to destroy it in order that, by its alternation of creation and destruction, the general end of life might be attained. At present we are compelled to admit that, if the vegetable cell is the seat of a phenomenon of reduction by which carbonic acid is decomposed into its elements, a similar phenomenon is produced in the animal cell. Non-azotised combinations, it is now known, can be formed in the interior of the animal cell. Alexander Schmidt was the first to observe that, after the addition of carbonic acid to blood, the total contents of carbonic acid diminished in certain circumstances. This observation furnishes direct support to the idea of a phenomenon of reduction. The blood globule plays, therefore, a part analogous to that played by chlorophyll in the vegetable cell in contact with the carbonic acid of the atmosphere. The only difference

which exists is, that in the blood-cell there is, besides, a process of oxidation going on which surpasses the process of reduction. Just as the chlorophyll of the vegetable cell absorbs carbonic acid, so does its colourless protoplasm absorb oxygen, and this corresponds completely to the absorption of oxygen by the blood-cell in the lungs.

The Fauna of the South-west Coast of France.—Examining a great number of specimens from dredgings and soundings off the south-west coast of France, M. Fischer has made out the following species of Molluscs:—*Nærea costellata* (Deshayes); *Psammobia costulata* (Turton); *Lepton nitidum* (Jeffreys); *Leda tenuis* (Phillipi); *Arca pectunculoides* (Scacchi); *Lima subauriculata* (Montagu); *Scissurella crispata* (Fleming); *Cyclostrema nitens* (Phillipi); *Rissoa soluta* (Forbes); *Eulima bilineata* (Alder); *Mangelia borealis* (Loeven); *Mangelia elegans* (Scacchi), &c.—most of which have not hitherto been found in France. M. Fischer points out that it was impossible to obtain these species along these coasts, on account of the shore sloping gradually towards the west, so as to form a vast terrace bounded by depths of more than 200 fathoms. In England and in Norway they are dredged a short distance from the shore at great depths. The existence of the submarine terrace on the French coast has made it necessary to go several leagues out to look for the deep fauna; hence the apparent poverty of the French shore. It has been remarked by English authors, says M. Fischer, that a certain number, at great depths in the Mediterranean, are found in the English seas, without being present at intermediate stations; and they have therefore concluded, without any geological evidence, that at the end of the tertiary epoch the Mediterranean communicated with the ocean by an arm of the sea traversing Aquitaine and Languedoc. The result of these dredgings spoils this conclusion, for it clearly demonstrates the continuity of the habitat of the species once considered to be localised at points so remote.—*L'Institut*, Dec. 9.

The relation of the Auditory Organ in Cephalophora to the Nervous Ganglia.—A memoir was read to the French Academy, at its first November meeting, by M. Lacaze-Duthiers, on this subject. From observation on more than thirty species of gasteropoda, he can no longer share the opinion of MM. Leydig, Claparède, and Huxley, which points so clearly to the union of the otolite and the pedal ganglion. The acoustic nerve always takes its origin in the subœsophageal or cerebral ganglion, and though the auditory pouch may rest upon the locomotor pedal ganglion, its nerve never arises in this ganglion. So that the subœsophageal ganglion presides over all the organs of sense, which, to the pedal ganglion more particularly, motion is to be attributed. Sensibility and motor power are, therefore, distinct in all the groups of the cephalophorous molluscs as they are in vertebrate animals.

A new Batrachian.—At the meeting of the Zoological Society, on Nov. 12, Mr. St. George Mivart gave a description of a new species of frog in his own collection, which appeared to constitute a new genus and species of Batrachians, and which he proposed to call *Pachybatrachus robustus.*

Nature-painted Butterflies.—Dr. John Lowe, of Lynn, has sent us a note in reference to a notice in one of our recent numbers, of a collection of

butterflies, the wings of which are mounted and the bodies painted in sepia. He says: "It may interest your readers to know of a somewhat differently prepared collection, the work of a deceased lady, in this neighbourhood, which for beauty and perfection exceeds anything I have yet seen. They comprise two large volumes, one of butterflies, the other of moths, and though executed between thirty and forty years ago, retain all the brilliancy of the recent insects. The mode of mounting is as follows: The wings, carefully separated, are laid on the paper, which is previously gummed to the exact extent of the surface to be covered, the surplus gum removed, blotting-paper laid over them and pressure applied until they are dry. The wings are then removed, leaving a correctly nature-printed representation. The body, legs and antennæ are then painted in colours. In the collection are many of our rarest British species, such as the Camberwell Beauty, &c. They are not always laid out open, but are in every natural position: with expanded wings, in postures of rest, or poised upon leaves or flowers painted with extreme accuracy and with much artistic talent. The sheets on which they are displayed are mounted in a volume, furnished with a lock, and are thus kept from light and air. The result in the preservation of all their colours is most remarkable."

Naturalist's Directory.—The excellent directory, which is being published in the Proceedings of the *Essex Institute*, Salem, United States, is not yet completed. In the two last numbers of these Proceedings (Nos. VI. and VII., vol. 5), the list of writers on insects is continued and completed; those on crustaceans, worms, molluscs, radiates, protozoa, and parasites, are also completed. An appendix is furnished supplying names received since printing some of the lists. This includes five pages of names of workers in the following subjects:—geology, physical geography, minerals, metallurgy, palæontology, anatomy and physiology, microscopy, botany, archæology, ethnology, mammals, birds, fishes, insects, and molluscs.

A Catalogue of the North American Birds in the Museum of the *Essex Institute* has been prepared by Dr. Elliott Coues, and is published in No. VII. of the *Proceedings* of the Essex Institute.

Floscularia Campanulata.—There is a very excellent paper, accompanied by two good illustrations, on this subject in the last volume of the *Proceedings of the Bristol Naturalists Society*, which we have just received. The paper was read about twelve months since by Dr. C. T. Hudson, M.A., but it contains such excellent matter that we have much pleasure in bringing it under the notice of our readers. The author deals with some important anatomical points, and he gives some interesting facts in connection with the habits of Floscularia.

The Silkworm culture.—A paper on this subject, in which the history of the progress of the silkworm disease, and of the mode of combating it, is accurately and popularly stated, will be found in the *Revue des Deux Mondes* for October. It is from the pen of M. Payen, of the Academy of Sciences. The same number contains a sketchy but instructive paper by M. Laugel on the eye and vision, in which the recent works of Helmholtz and Max Schultze are reviewed.

Structure of the Shell of Crustacea.—Mr. J. Slade has a short paper in the *Journal of the Quekett Club* for October, in which he describes the

microscopic structure of the shell of crustacea. He refers to the inquiries of Williamson, Carpenter, and Huxley, and agrees with the latter in denying the cellular character of the uppermost of the inner layers. This quite agrees with our own observations on this point. It is to be regretted that no illustrations are given.

Deep-sea Dredging.—On Thursday, December 17, Dr. B. W. Carpenter read the report of his researches in the North Atlantic, undertaken under the direction of the Government. It would be impossible to give anything like a satisfactory summary of the results he has arrived at in the short space of a paragraph. We may, however, mention one or two facts ascertained by Dr. Carpenter and Professor Wyville Thompson: 1. They have found at a certain point between the north of Scotland and the Faroe Islands that the water at the sea-bottom, at a depth of 500 fathoms, has a temperature of 32° Fahr., while the surface temperature was, as usual 52°. From the bottom of the sea were dredged up several boreal species and a large quantity of mud containing the peculiar protoplasmic substance which Professor Huxley has termed *Bathybius.* 2. They have found that (so far as their researches went) the sea-bottom over which the Gulf-stream flows consists of a calcareous mud composed of living and dead Globigerinæ, and coccoliths, and coccospheres embedded in *Bathybius,* and seeming to have the same relation to it that the spicules of sponges or of Radiolaria do to the soft parts of those animals. 3. That vegetable life is entirely absent at these depths, the *Bathybius* seeming to be a sort of Protozoan of low type, and capable, like plants, of sustaining itself on the mineral kingdom alone. 4. That dredging may, with suitable apparatus, be carried on at almost any depth in the ocean. Dr. Carpenter is disposed to look on the cretaceous sea-bottom as the still-existing Chalk-formation, and he thinks this view finds support in the fact that its basis is nearly the same as that of the cretaceous deposits, that certain shells common to both exist, and that siliceous sponges are extremely abundant. Dr. Carpenter is now busily engaged in preparing an account of the Rhizopods collected during the expedition, and Professor Wyville Thompson is equally busily occupied with the siliceous sponges. Professor Huxley and Professor Frankland have also special sections allotted to them. Among the novelties we may state that these researches have clearly demonstrated the sponge character of *Hyalonema.*

The Fauna of the Montana Territory in the Rocky Mountains has been dealt with by Dr. J. G. Cooper in the *American Naturalist* for December. Dr. Cooper's paper is more general than technically zoological, but will be read with interest.

The Habits of Spiders have been very well and graphically described in this journal by Mr. J. H. Emerton. He takes as instance the *Epeira vulgaris,* and gives the details of his numerous observations of this Arachnid.

The Colorado Potato-Bug (*Doryphora* 10 *lineata*) is the subject of a very long paper, accompanied by numerous woodcuts, in the *American Entomologist* for November. This, the third number of the journal, seems to contain a good deal of gossiping information of interest to entomologists generally.

The ciliary Muscle in Fish, Birds, and Quadrupeds is the title of a paper by Mr. R. J. Lee, in the *Journal of Anatomy* for November. We must say that

we are dissatisfied with the author's facts and illustrations. If there is any point in connection with the ciliary muscle of great interest it is the minute relations which exist between it and the choroid on one hand and it and the cornea on the other. These, it seems to us, have in great measure been overlooked by Mr. Lee, who gives us enlarged but not microscopic figures of his dissections. If Mr. Lee would look over some of the specimens in Mr. Lockhart Clarke's collection he would then see how much good work he has left undone. *En passant*, we would remark that the "Reports" on Anatomy and Physiology in this journal are the most carefully and discriminately arranged abstracts we have ever seen.

The Lymphoid Organs of Amphibia.—A paper by Herr Dr. Toldt has been read on this subject before the Vienna Academy. The so-called *thyroid* gland in frogs is described, and its relations in functional analogy with the lymphatic glands in Mammalia pointed out. The situation and structure of the organ in the amphibia called the *thymus* are described in detail, and its probable functions indicated.—*L'Institut*, Dec. 2.

POPULAR SCIENCE REVIEW.

CONTENTS.—No. XXXI.

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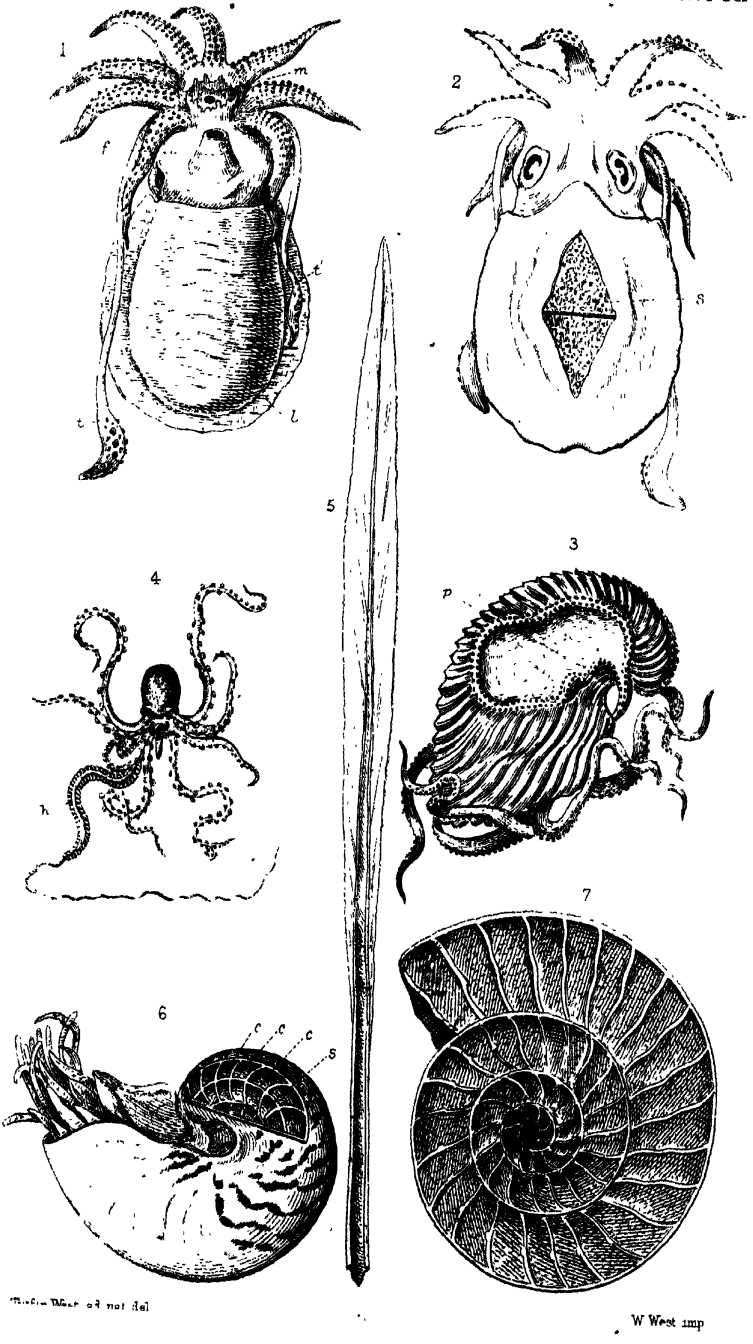
Plate XLI



W West imp

THE CUTTLE-FISH.

BY ST. GEORGE MIVART, F.Z.S.

Lecturer on Comparative Anatomy at St. Mary's Hospital.

[PLATE XLI.]

IN the number of the Popular Science Review of October last, we gave a short account of the structure of the Lobster, to serve as a type of one of the great primary groups into which the animal kingdom is divided. We now select another animal of an altogether different build to serve as a type of another great primary group.

The Cuttle-fish is really no *fish* at all, as we shall soon see, and is almost, if not quite, as unlike a true fish as we have already seen the lobster to be.

Its appearance is unprepossessing enough—a short swollen body (all soft externally—not shelly, as in the lobster), with a considerable head, from the crown of which radiate ten long arms, give it a fanciful resemblance to a great marine spider; not that there is any real affinity between the two, the spider being formed on the same type of structure as is the lobster.

The head (which is sometimes called the *prosoma*, or front body) contains the organs of sense, and the mouth opens in the middle of its upper surface, in the midst of the radiating arms.

The body, or abdomen (sometimes called *metasoma*, or hind body), is a great bag enclosing the circulating, digestive, and generative organs. This body is enclosed in a great fleshy envelope, which is called the *mantle* (or *pallium*), and which is firmly adherent to the body behind, but free in the front—like a smockfrock sewn down the back to the waistcoat beneath it, but quite unattached at the chest, where a space is left between the body and its investing garment. This space is called the *pallial chamber;* in it are placed the gills, and into it the intestine and certain ducts open.

On each side of the body the mantle is, as it were, pulled out into a sort of fin (fig. 1 *l*). On the front surface of the body a sort of pipe (termed the *funnel*) is placed, which is open at

each end. Its summit (fig. 1 *f*) projects upwards above the top margin of the mantle; its lower end opens into the pallial chamber.

The arms are ten in number:* eight of these are of moderate length; but two (called *tentacles*) are very long, retractile, and expanded at their ends (fig. 1 *t* and *t'*).

Each arm, on its inner surface, is furnished with a number of suckers (*acetabula*), each one of which may be compared to a small cupping glass on a short stalk.

Each acetabulum has a toothed horny margin, and its interior, when it is in a passive state, is nearly filled by a muscular papilla, or small fleshy mass. This papilla, however, can be contracted, and then occupies but a small space at the bottom of the cup.

The cuttle-fish seizes objects in this fashion. First it closely applies the horny margins of the acetabula to the surface of the object seized. It then immediately contracts the papillæ, and thus produces a vacuum inside each acetabulum, causing a most intimate adhesion by atmospheric pressure. Yet, in spite of the excessive tenacity of the grasp produced by the simultaneous action of hundreds of acetabula, the cuttle-fish can let go its hold in a moment, by simply relaxing the contraction of the papillæ, and allowing them to return to their passive condition. The male cuttle-fish has a certain space on one of its arms devoid of suckers.

On each side of the head there is a very large and brilliant eye, constructed on essentially the same plan as the human eye, except that there is no iris, its place seeming to be supplied by a deep groove which runs round the lens of the eye. Moreover, the transparent coat outside the lens, i.e. the *cornea*, is perforated, thus presenting permanently a condition which transitorily exists in higher animals.

When the cuttle-fish is irritated, peculiar flushes of colour pass over its skin. This appearance is produced by the pulling open, by the contraction of very small muscular fibres, of little bags of bright coloured and differently coloured pigment, and which little bags when in their contracted state appear as small dark specks on the skin. These little bags are termed *chromatophores*, i.e. "colour-carriers."

Everybody knows the cuttle-bone. Its technical name is *sepiostaire*. It is a cellular, calcareous substance, the use of which is problematical, as, although it is light (with its interspaces filled with air), it can hardly have much effect as a float. Perhaps it serves rather as a *point d'appui*, or possibly as a

* In the Poulpe, and certain other forms, there are but eight arms, whence such are termed Octopods.

protection to the animal while swimming backwards, situated as it is on the dorsal side of the body, and within the substance of the mantle or pallium. From its position it is termed a pallial shell (fig. 2 *s*).

The action of breathing is so performed as to have a certain resemblance to the respiratory actions in ourselves, as it is accompanied by alternate contractions and expansions of the body. The mantle is first expanded, and the consequence is an inrush of water into the pallial chamber in which lie the gills. Then the margin of the mantle is closely applied to the body (becoming, as it were, buttoned up by the application of three cartilaginous prominences to corresponding depressions) and afterwards contracted, driving the water violently out of the funnel, which is provided internally with a valve so constructed as to freely allow the egress of water, but to oppose its ingress. Locomotion and respiration are thus simultaneously effected, as the stream of water issuing from the funnel drives the cuttle-fish in an opposite direction—that is, backwards. This continual contraction and expansion of the mantle supplies the gills in the pallial chamber with a continually renewed supply of water for respiration.

The mouth of the cuttle-fish is situated, as before said, in the middle of the circle of arms and tentacles, and within its lip is a horny beak quite like the beak of a parrot, except that the lower jaw, instead of the upper one, is the longer. These jaws are moved by powerful muscles, and bite vertically, and are altogether very different from the jaws of such a creature as the lobster.

The tongue is a very peculiar organ, and one the presence of which characterises many creatures more or less allied to the cuttle-fish. It is termed an *odontophore* (tooth-bearer), and consists of an elongated ribbon-like structure (bearing small teeth), which plays to and fro, by means of special muscles, over a cartilaginous cushion, and acts much as a chain-saw. The mouth is moistened by the secretion of salivary glands, and there is a sack attached to the stomach which probably gives out a similar product. The gullet (which is furnished on one side with a crop) leads down into a gizzard-like stomach. The liver is much more solid and compact than in the lobster, thus approximating to the structure of higher animals.

The cuttle-fish is provided with another, and a very peculiar gland, the secretion of which is of great use in helping it to escape its enemies. This is the ink-bag, which opens near the arms, and which produces an intensely coloured substance. When alarmed, the cuttle-fish suddenly expels some of this very dark product, which so colours the surrounding water that the animal is enabled to escape under cover of the obscurity so

occasioned, like the gods of Homer rescued from perils on the plains of Troy by an overshadowing cloud. This "ink" is so capable of preservation, that some extinct fossil forms have had their portraits taken by means of the very pigment they had themselves secreted so many ages bygone, and which had been, of course, buried with them. Certain kinds of cuttle-fish which have the cuttle-bone (or sepiostaire) replaced by an elongated horny structure amazingly like a quill pen (fig. 5), have been called on this account, and on account of their ink-bag, "pen-and-ink fishes."

The circulating system of true blood is much more complete than in the lobster. The blood is brought back from all parts of the body to a large vein (the *vena cava*), which bifurcates its branches, going one to each of the two gills. As soon as each branch has arrived at the base of the gill to which it is destined, it dilates into a contractile sac called a "branchial heart," which pumps the blood up into the gill. The two gills are formed on essentially the same type of structure as are the gills of the lobster, being similarly formed for subjecting the venous blood to the oxygenating action of the air mechanically mixed up in the water. As in the lobster, also, they are destitute of vibratile cilia. The very substance, however, of the gills themselves is contractile, and the blood having traversed them is transmitted in its aërated state to the ventricle, or systemic heart. It reaches that ventricle by two contractile vessels, which may be considered as auricles, each auricle taking origin at the root of one of the gills, and passing thence to the systemic heart, which thus (as also in the lobster) distributes to the system oxygenated blood only.

The kidneys are in the form of two bunches of grapes, situated one bunch on each of the branches of the *vena cava*. Each is placed in a chamber termed the *atrial* or water chamber. This chamber is part of the true somatic or body cavity, and is separated from the perivisceral cavity (*i.e.* from that which surrounds the intestine, &c.) by the mesentery enclosing the viscera.

The renal secretion (urine) is washed out, as it were, by the water of the atrial chamber, which chamber communicates with the pallial cavity by two small openings, one on each side of the anus.

The nervous system is well developed, though very concentrated, and consists mainly of what are primitively and essentially three pairs of ganglia, named respectively "cerebral," "pedal," and "parieto-splanchesic." The two latter, however, are quite fused together.

The cerebral ganglia may be considered as representing the brain, and thence issue the nerves of sight and smell. This

brain is close to the anterior part of the alimentary canal, and is sheltered by a cartilaginous framework, which is thus a foreshadowing, as it were, of part of the true internal skeleton (viz. the skull) of higher animals.

Unlike the lobster, all the muscles in the cuttle-fish are composed of unstriated fibres.

The organs of smell consist of a pit between each eye and the tentacles, and, as has been said, their nerves are supplied by the cerebral ganglia. The eye has been already noticed.

The ears are two small sacks, one placed on each side of the head in the lower part of the cartilage before mentioned, thus strongly recalling to mind the internal ears of higher animals. Each sack contains certain hard parts termed *otolithes.* The auditory nerves come not from the cerebral, but from the pedal ganglia.

The sense of taste is probably effected by the agency of papillæ situated at the base of the tongue.

With regard to the reproductive system, each individual is either male or female, and the male, as has been said, has a suckerless space on one of his arms on the left side of the body. The sexual gland, whether testis or ovary, is situated at the lower end of the body, and its duct opens into the pallial chamber. Each sex is also provided with an accessory gland which in the female coats the eggs with a viscid substance, which connects them together, so that they resemble a bunch of grapes. The corresponding gland in the male, as we before saw to be the case in the lobster, coats the spermatozoa with its secretion, and thus they become enclosed in peculiar cases which from their office are termed *Spermatophores*, and which possess the property of expanding with force when wetted, and thus, becoming everted, scatter the contained spermatozoa.

During the congress of the sexes, the male transfers these bodies from his own pallial chamber into that of the female.

The egg is shaped much like that of the common fowl, but is full of yelk. Only part of this undergoes division, and the divided surface (*blastoderm*) gradually spreads itself all over the yelk.

It is the hæmal surface of the body which is first formed, and not, as in the lobster, and in higher animals, that part of the body at which the nervous system is situated. The surface of the blastoderm soon exhibits rudiments of the principal external parts. In the centre appears what is ultimately the lower end of the body. On each side of this a fold is developed, and these two folds afterwards unite to form the funnel in the adult. At the anterior ends of these two folds respectively the eyes come into view, and between them the indication of the future mouth in the middle line in front, and of the future

anus in the middle line behind. On each side five small and similar buds appear, and these become ultimately the eight arms and the two tentacles. After a little time the essential similarity of the cuttle-fish to other nearly allied forms, such as the whelk or snail, becomes more evident as the body is more and more elevated above the egg. Then, while the embryo is still only bilaterally symmetrical, it is plainly to be seen that the incipient arms are nothing more than external outgrowths from, and prolongations of, that organ on which the whelk, snail and such creatures walk, viz. the foot, while the fold on each side above the incipient arms, and which is ultimately to become half the funnel, is seen to answer to a similarly placed expansion in certain exceptionally-formed creatures allied to the whelk, and which expansions have been named *epipodia.*

As development goes on, the mouth is gradually brought into the centre of the radiating arms, which increase greatly in length, while the body mounts higher and higher, the pallial chamber gradually assumes its permanent form, the two halves of the syphon unite, and the intestine becomes convoluted, &c.

Such is a short account of the more salient points in the structure of the cuttle-fish, which is a nocturnal marine animal preying on fishes, lobsters, and other sea-dwelling animals, which it seizes in its wonderfully tenacious grasp, while it tears them to pieces with its powerful horny jaws.

The cuttle-fish is interesting, because it presents us with the most fully developed and complex condition of that type of structure to which it belongs. All snails, slugs, whelks, limpets, periwinkles, pteropods,* the argonaut, the nautilus, the extinct ammonites and belemnites, &c., all pretty closely resemble the cuttle-fish in structure; while even all oysters, cockles, mussels, and the exceedingly numerous other creatures of that kind belong to the same essential type as does the cuttle-fish; the whole of the above enumerated forms, with their allies, constituting one great primary division of the animal kingdom called MOLLUSCA, just as all the creatures similarly allied to the lobster constitute another such great primary division termed ANNULOSA.

A few words must be said, however, about some of the above-mentioned forms which most closely resemble the cuttle-fish in build, and are on that account associated with it in a subordinate group termed a class, and to which class the name *Cephalopoda* has been applied, on account of the aggregation of the

* These are small, free, surface-swimming creatures, which abound in myriads on the surface of the open ocean, both in hot and in cold latitudes. n the latter they form the principal food of the whale.

arms round the head. These forms are the argonaut and the nautilus and ammonites.

The argonaut, sometimes called the paper-sailor, is best known by its beautifully delicate and translucent shell (Pl. XLI. fig. 3), which, unlike the cuttle bone, has no organic connection with the body of the animal possessing it.

The creature has eight arms, but two of these are enormously expanded towards their ends; and the popular belief was that the argonaut sat in its shell with these expanded arms raised to act as sails, while with the others it propelled its boat by rowing. Its mode of locomotion, however, is really by the ejection of water from the funnel, and these expanded arms serve the singular office of secreting the shell over which they are externally applied (Pl. XLI. fig. 3). Hence this shell is termed a "pedal shell," from its mode of formation, while the sepiostaire of the cuttle-fish is called a "pallial shell," because it is formed in the substance of the mantle.

The argonaut presents another very singular peculiarity. For a long time—indeed, until the last few years—none but females were found; but Cuvier discovered in the pallial chamber of one of these an elongated organised body covered with suckers, and containing a hollow chamber. The great naturalist placed it amongst the parasitic worms, and named it *Hectocotylus*. Subsequently Dr. Kölliker noticed the presence of chromatophores, and also of a multitude of spermatozoa in the hollow chamber; and he concluded that the organism was a male argonaut, which thus would be an animal quite dissimilar in form to the female, and rudimentary in size as compared to her. Such sexual discrepancy, however, is well known to exist in many of the lower animals; so that the idea, though startling, was by no means incredible.

Since Kölliker's observations, however, the true male (fig. 4) has been found by Henry Miller and Verany of Genoa, and it turns out to be an animal like the female, except that it is considerably smaller, and has no shell and no expanded arms. What, then, is the *Hectocotylus* of Cuvier? Why, it turns out to be nothing less than one of the tentacles of the male (fig. 4 *h*), who, in paying his addresses, not only offers his hand, or rather arm, but actually leaves it behind him in the pallial chamber of the female!

This peculiar action is not known to occur in any other cephalopod; nevertheless, all of them are sexually distinguished by some modification of one of the arms, as has been already noticed with regard to our type.

The nautilus (fig. 6) is an animal more different from the cuttle-fish than is the argonaut, though still belonging to the same class. It is found in the Chinese Sea and Indian Ocean, but is

a rare animal. Unlike the cuttle-fish, it has a large shell, which, though pallial in its origin, is external in position. Moreover this shell is divided transversely by a succession of partitions, connected by a tube traversing them, all termed the "siphuncle" (fig. 6 *s*). The animal itself only inhabits the last chamber of its shell, which serves well for its shelter and protection. The nautilus differs from the cuttle-fish mainly in the presence of this peculiar external shell, in having four gills in the mantle cavity instead of only two; in there being a great number of tentacles all devoid of acetabula, instead of not more than ten, and these *with* acetabula; in being destitute of branchial hearts; in having the beak partly calcareous, instead of entirely horny; and, lastly, in having no ink-bag, the protection afforded by its shell no doubt rendering the sheltering obscurity producible by such a secretion much less necessary.

The characters of this animal are of interest because it is the type of a very large group of cephalopods, which, as living forms, have now passed away from the surface of this planet—that is, unless deep dredging should bring to light any ancient form still holding out, as has been lately done by Dr. Carpenter for Echinoderms.

The ammonites (fig. 7) are fossil forms, essentially resembling the nautilus as to the hard parts, and no doubt similar also in their softer structures. The nautilus, the ammonites and their allies appear, one or other, to have existed during the whole primary and secondary geological periods; but what is more singular is that these four-gilled cephalopods appear in ancient times to have represented in the economy of nature creatures of the whelk class, which do not then appear to have existed in any number, while with the progress of time the four-gilled cephalopods have all but disappeared, while the whelk-like class of molluscs has increased more and more, and now has completely taken the place of their more highly organised and complex predecessors.

Returning once more to the cuttle-fish (and recalling to mind the concluding observations previously made as to the lobster), we may note sundry fundamental facts of structure.

1. The nervous system is disposed in three pairs of ganglia, and is not in the form of a chain either dorsal or ventral.

2. No elongated solid structure separates the nervous centres from the alimentary canal.

3. The most anterior part of the alimentary canal passes between the nervous centres.

4. The limbs are more than four in number.

5. There is no portal system.

6. In development no visceral clefts appear.

7. The jaws are not modified limbs.

8. In development the embryo does not present a longitudinal median groove.

9. The body is soft, is protected by a calcareous shell, and not by a hard chitinous envelope.

10. It does not consist of a longitudinal series of similar segments, either internally or externally.

11. The heart is auriculo-ventricular in structure.

12. In the embryo the hæmal not the neural surface is first developed.

The cuttle-fish differs from man by those of the above characters which are numbered 1, 2, 3, 4, 5, 6, 10, and 12.

It differs from the lobster, on the other hand, by those of the above characters which are numbered 1, 7, 9, 10, 11, and 12.

The cuttle-fish, moreover, agrees with the other cephalopods, and with all snails, slugs, whelks, limpets, periwinkles, and pteropods, not only in the above twelve characters, but also in the presence of a head and of an odontophore; in the gills not being in the form of lamellar plates; and in the shell, whatever its form, being single, and not divided into two valves, one on the right and the other on the left side of the animal, as is the case in all oysters, mussels, cockles, and other similar creatures.

No animal known to exist now, or ever to have existed in past time, presents us with any intermediate condition tending to bridge over the chasm which yawns between the cuttle-fish type and the lobster type on the one hand, or between the cuttle-fish type and the human type on the other.

Other types, however, exist, which are perhaps as distinct from any of these as they are from each other. Hereafter one of the other types here alluded to may form the subject of ye another zoological sketch.

EXPLANATION OF PLATE.*

FIG. 1. Sepia. Ventral aspect.

t tentacle.	*m* mouth.
t' ditto, partly retracted.	*l* lateral fin.
f funnel.	

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* These figures have been drawn (by the kind permission of the Museum Committee of the Royal College of Surgeons) from some specimens which form part of the educational series lately added so advantageously to the College of Surgeons' Museum by its zealous Curator, Mr. W. H. Flower, F.R.S.

FIG. 2. Sepia. Dorsal aspect.
s sepiostaire, the mantle being cut and reflected.

„ 3. Female Argonaut.
p expanded arm applied to the outside of the pedal shell.

„ 4. Male Argonaut.
h the arm which becomes detached (hectocotylus).

„ 5. Pen.

„ 6. Nautilus, with its external siphunculate chambered pallial shell partly cut, to show *s* the siphuncle traversing the septa separating *c c c*, some of the chambers.

„ 7. An Ammonite vertically bisected, to show the whole series of chambers.

THE NATURE OF THE INTERIOR OF THE EARTH.

By DAVID FORBES, F.R.S., &c.

WHAT the central mass of the globe upon which we live consists of, is a question which most educated men have doubtless at some time or other asked themselves, without, it is surmised, eliciting a response which could in any degree satisfy their natural curiosity; most probably the idea which would first suggest itself, is, that its internal mass must be composed of solid rock similar to what is seen forming its mountain chains, the foundations of its continents and the basins which contain its seas. The belief in this hypothesis would, however, be rudely shaken upon the first experience of the effects of an earthquake, or the sight of a volcano in activity, for such phenomena could not but at once suggest grave doubts as to whether the earth could be in reality either so solid or so stable as at first thought one felt inclined to believe.

Such phenomena, however rare they may be in Great Britain, are not exceptional, as the intelligence from all quarters of the globe testifies. During the past year, scarcely a mail has arrived without bringing tidings from some part or other of volcanic outbursts or earthquakes, several of them fearfully disastrous; now taking place near the North Pole, as in Iceland or Alaska, then in the Antarctic regions of Polynesia or New Zealand, whilst still nearer home Vesuvius and Etna have alternated in fiery activity. Extensive eruptions and earthquakes have also occurred within the last twelve months in the West Indies, Sandwich Islands, California, Mexico, Nicaragua, and in various parts of the Andes of South America; yet even this enumeration is far from being a complete one.

Nor have the continents, or, as the Spaniards say, "Tierra firma," been alone so affected, for numerous accounts also bear witness that the depths of the sea have been equally disturbed. In the Mediterranean, for example, the sea bottom at Santorin has been so elevated by volcanic action as to have become dry land, where only lately was deep water in which the largest ships afloat could ride at anchor; and submarine eruptions of great

intensity have been reported in the Pacific Ocean off the coast of Mexico, as well as in the Atlantic, between Africa and South America.

Notwithstanding that the records of such phenomena in more ancient times are extremely defective, a retrospect of such as have been observed indicates that they have not diminished in frequency in later periods, and the tabular statements of known European eruptions and earthquakes made by Professor Phillips and Mr. Mallet respectively, show that their number has gradually increased per century, from the fourth up to the nineteenth, and that since that early period by far the greatest number in any one century has occurred in the last and present century.

It is not to be wondered at, therefore, that the question, What does the central mass of our sphere consist of? should be one possessing more than ordinary popular as well as scientific interest; and for this reason it is here proposed to submit a concise sketch of the opinions which from time to time have been brought forward by different writers on the subject, along with a notice of the arguments used in their support or advanced in opposition, thereby to enable some independent if not impartial judgment to be formed by our readers.

The greatest depth hitherto attained by direct explorations into the substance of the earth's surface has not yet reached 5000 feet, and it is scarcely to be expected that any much greater depth can be arrived at, for which reason, notwithstanding the many and valuable data resulting from such explorations, it appears self-evident, in order to pursue this enquiry further, that we must mainly rely upon the less direct evidence furnished by calling in the assistance of the natural sciences.

According to the different hypotheses advanced at various times with respect to the physical condition of the earth's mass, our sphere has been respectively represented as a globe—

1. Composed of a relatively thin external crust or shell, filled with matter in a state of molten liquidity;
2. Nearly, if not quite, solid to the core;
3. Composed of a solid external shell separated from an equally solid nucleus by a zone of intermediate molten matter;
4. Consisting of an external solid shell, filled with enormously compressed gaseous matter.

The first of these four hypotheses, or that which regards the Earth as being a sphere of molten matter, surrounded by a comparatively thin solid external shell or crust, is the one more generally accepted by geologists and such men of science as prefer basing their deductions entirely upon facts elicited from the direct examination of so much of the earth's exterior as is accessible to man. Amongst the facts advanced in support of this theory, the following are probably the most important.

1. The results of a large number of experiments, made in mines and boreholes in various parts of the world, affording conclusive evidence that the temperature of the earth, as deep down as has yet been explored from the surface, increases in direct ratio as we descend towards its centre.

It has been found a matter of much difficulty, owing, as might be expected, to the interference of local causes, to determine with exactitude the true general rate of such increase in temperature downwards, but all observers agree in regarding it as somewhere between 1° and 2° Fahrenheit for every hundred feet in depth from the surface.

2. Numerous observations of the temperature of hot and deep-seated springs and Artesian wells, which prove that the temperature of the water increases with the depth of its source, and confirm the results of the experiments made in mines.

3. The great currents of molten lava emitted from the volcanic orifices in all quarters of the globe, which, as in the space enclosed between America, Asia, and Australasia, may present one vast scene of volcanic activity, covering a large area of the face of the globe, and bearing testimony to the vast accumulation of molten matter which must necessarily exist in its interior.

4. The numerous analyses of the lavas and other products of volcanoes, which prove them to be quite analogous in mineralogical and chemical constitution, without reference to what parts of the world, however distant from one another, in which they may have been ejected, and lead to the inference that they must all have proceeded from some one great hypogene source, and not be products of any mere local action.

5. The evidence afforded by geological observation that eruptions of rock masses, resembling those of our modern volcanoes, have, since the earliest periods, played a similar part in the geological history of the earth.

6. The occurrence of great faults (more or less vertical), formed by the elevation and depression of large areas of the rock formations which constitute the external crust of the earth.

These latter phenomena lead to the inference that the external crust itself cannot, in depth, rest upon an unyielding mass of matter in the solid state, but that it must be superposed upon some more or less fluid substance, which, by its mobility, can, when some one portion of the crust above has subsided or been let down, become displaced and make room for itself by elevating, or, as it were, floating up, some other part of the same.

As far as explorations have as yet been carried down into the earth, the direct increase of temperature with the depth has been fully established; and, as no facts are known at present which can invalidate the supposition that the same, or a somewhat similar, ratio holds good in still greater depth, it is perfectly

correct and justifiable reasoning to assume that such is actually the case: and it follows, therefore, as a natural consequence, that a temperature above 3,000° degrees—representing a heat sufficient to melt rocks like granite, &c.—will be found at a depth of some forty miles from the surface (more or less, according to the rate of increase used in the calculation), or, in other words, that at that comparatively small depth an internal mass of molten matter exists in the interior of the earth.

Coming now to the consideration of the second hypothesis, which represents the earth as being nearly, if not quite, solid to the core, we find that it is founded upon such purely astronomical evidence as to altogether ignore any data which the geologist can eliminate from the direct study of the earth itself. The late Mr. Hopkins of Cambridge, who first advanced this hypothesis, appears to have arrived at this conclusion, from observing, when two clock pendulums are set agoing equal in all other respects, except that whilst the bob of the one is solid that of the other is hollow and filled with mercury, that the latter will swing somewhat faster than the former.

Applying this observation to the consideration of the movements of the earth in space, Mr. Hopkins, by an extremely elaborate course of mathematical reasoning and calculation, demonstrated that the earth must be nearly, if not quite, solid; since, if it was merely a comparatively thin shell, filled with liquid matter, the ratio of certain of its movements (precession and nutation) would differ very considerably from what they are actually known to be—conclusions which subsequently were understood to be further confirmed and verified by the arguments and calculations of Sir William Thomson and Archdeacon Pratt.

Although it might have been surmised that the conditions of a pendulum-bob of polished glass, filled with equally slippery non-adhesive mercury and swinging at the end of a rod, must be very different from those of our nearly spherical globe, filled with molten, but viscid or sticky, lava and revolving upon its own axis, geologists at once felt themselves put to utter confusion by this "dictum" of the astronomers and mathematicians; and, being none of them sufficiently versed in either astronomy or mathematics as to be able to submit the reasoning or calculations to any exact scrutiny, felt themselves—reluctantly, no doubt—compelled to bow to the decision of such eminent authorities.

So stood the matter until last summer, when fortunately M. Delaunay, an authority equally eminent as mathematician and astronomer, was induced to undertake the reconsideration of the problem; a labour which has not only resulted in altogether reversing the above decision and demonstrating the complete fallacy of the premises upon which the reasoning was founded,

but which further proved, experimentally, that a sphere filled with liquid matter would, under the circumstances, behave in precisely similar manner as an entirely solid one; and, consequently, that the fact of the earth being either solid or liquid in its interior could not only have no influence whatever on the rates of precession and nutation, but could not be used as a means of deciding anything as to the real thickness of the earth's crust.

The astronomical arguments in favour of a solid, or nearly solid, globe being thus altogether invalidated, it remains to enquire as to whether any other facts can be advanced in support of this hypothesis.

In 1849 Professor J. Thomson announced, from theoretical considerations, that the fusing points of bodies must become elevated when subjected to pressure, or, in other words, that under the influence of pressure bodies would require more heat to melt them or keep them in the molten condition; a view which was, in 1850, confirmed by Bunsen's experiments on spermaceti and paraffine, and still further corroborated, in 1854, by the more complete experiments of Hopkins on these bodies, as well as on wax and sulphur.

Reasoning upon these facts as a basis, Bunsen argued that the earth could not be other than solid to the core, since the enormous pressure accumulated at its centre would cause its internal substance to become so infusible that it could not remain in the molten state; and this opinion was adopted by Hopkins, as confirming the conclusions which, as before mentioned, he imagined had been proved by astronomical deductions.

If we now enquire into the value of these data, we will also find that they are not entitled to much confidence.

In the first place it is assuming that our earth is made up of substances like the wax, spermaceti, paraffine or sulphur experimented upon by Bunsen and Hopkins, and which are in nature about as diametrically opposite to what we know the earth must be composed of, as could well be selected for comparison.

Secondly, on examining into the details of the experimental results, it appears, that although the melting points of these bodies undoubtedly became higher under the influence of pressure, that the ratio of their so doing did not continue the same in proportion as the pressure was augmented, but on the contrary diminished after a certain point was reached, thus leading to the inference drawn some time back by the author of this communication, that bodies after attaining their point of maximum density may not become more infusible by increased pressure, but, on the contrary, may possibly become even more fusible as the pressure is still further augmented.

Thirdly, the experiments made by Hopkins upon metallic substances gave totally different results, and proved that the melting point of such bodies is not elevated by pressure: may it not be asked, therefore, how these results have been so completely ignored, and upon what principle do the supporters of this hypothesis adopt conclusions drawn from experiments made upon a most unlikely class of bodies, to the exclusion of those upon substances which, as will be seen in the course of this enquiry, are most probably present in the earth's interior in very large quantity?

Fourthly and lastly, it may be mentioned that, long after the views of Bunsen and Hopkins, as regards the application of these arguments to explaining the nature of the interior of the earth, were brought forward, we have the testimony of Mr. Fairbairn in 1861 that the later experiments on the effects of (much greater) pressures made by Mr. Hopkins and himself had caused that gentleman to greatly modify his opinions, and led him "to the belief that it is only in the more compressible substances that the law holds true."

The above remarks will show how little reliance can be placed in arguments as to the entire solidity of the globe, based upon the effects of pressure in producing consolidation; assuming, however, for argument's sake, that the materials composing the earth's mass do become more and more infusible according as they are situated nearer to its centre, it must still be remembered, on the other hand, that incontrovertible evidence has been produced by geologists to prove that the temperature or heat downwards from the surface also increases in direct ratio, and there is no sufficient proof in the results of Bunsen's and Hopkins's experiments to demonstrate that this augmentation in temperature would not more than counteract any tendency to solidity or increase of infusibility in the substances themselves arising from the effect of pressure.

The hypothesis that the earth was essentially solid necessitated that the phenomena of volcanoes should be explained upon the supposition that they had their sources in numerous small local basins scattered over the globe—a view which seems altogether incompatible with the results of chemical and mineralogical investigation, which proves that the ejected products are identical in constitution even if taken from the vents which are most distant from one another.

The late researches of Professor Palmieri of Naples point out that distinct tidal phenomena can be recognised in the eruptions of Vesuvius: should these observations be confirmed, they must be considered as very strong evidence against any theory of volcanic action supposed to have its origin in mere local sources.

The third hypothesis, which likens the earth to a gigantic

egg, having a solid shell and yolk separated from one another by a molten fluid which represents the white of the egg, is a species of hybrid between the first and second theories of the earth's constitution. Evidently intended as a sort of half-way compromise between them, it, like most half measures, will not probably meet with the approval of the supporters of either of the preceding theories.

If the astronomers have difficulty in reconciling the motions of the earth in the heavens, when the earth was imagined to possess an entirely fluid interior, it seems probable that still greater difficulty will be found in doing so when this view is rendered even more complicated by assuming that a sphere of solid matter floats, as it were suspended, in the aforesaid liquid interior.

The geologists and others who pin their faith to what they can deduce from direct observation may possibly not make any great opposition to such an hypothesis, since the main facts of geology are accounted for, if it be only granted that the earth at a certain depth below its exterior is in a molten condition; but they will certainly regard this idea of the earth's interior as being unnecessarily complicated, and not be prepared to give it any active support until good reasons are brought forward to explain why such an internal nucleus is believed to exist.

The idea of the existence of such a central nucleus is based upon the views and before-mentioned experiments of Bunsen, who maintained that, owing to the enormous pressure which, according to him, would accumulate at the centre of the earth, solidification must take place, commencing first at the centre and proceeding outwards towards the exterior.

How far the actual pressure and assumed consolidation at the centre would be counteracted by the expansion of the materials forming the interior of the earth, by the effects of the laws of gravitation, and by the acknowledged increase in temperature in depth, are questions which must be answered before such an hypothesis can be accepted; for at present absolutely nothing is known of the effects of such enormous pressures as have here to be taken into consideration as could warrant the expectation of obtaining a correct solution of this problem by arguments built upon so uncertain a foundation; and, as before mentioned, M. Delaunay has already given proof of how some of our most able mathematicians and astronomers have already been induced to advance and support an untenable hypothesis as to the constitution of the earth, owing to their having based their reasoning and calculations upon altogether fallacious premises.

The fourth and last hypothesis which we have to consider is, that the earth consists of an external shell filled with enormously compressed gases.

This hypothesis is purely theoretical, and in no way supported by direct observation. It originated in the assumption that the central parts of the globe cannot consist of such substances as we find in its crust, as otherwise the condensation of such bodies under the accumulating pressure acting towards the centre would cause the globe to possess a far greater mean density than $5\frac{1}{2}$ times that of water, which in actuality we know is the case.

This assumption is based entirely upon the supposition that bodies become more dense in *direct* ratio to the pressure to which they are subjected; according to which idea, air at a depth of about 80 miles below the surface should be as dense as water, which in its turn at some 360 miles' depth should be as heavy as mercury; and a solid like clay, which at the surface weighs about 125 pounds per cubic foot, ought to become so much condensed that a cubic foot would there weigh above 6 tons. It is for this reason contended that the central mass must consist of matter of extreme lightness (at the surface), such as gases which, upon being subject to such enormous pressure in the centre of the earth, could not assume a greater density than would fulfil the required conditions, as above explained.

The experimental investigations which have been made into the compressibility of substances do not, however, prove any such unlimited rate of condensation, and demonstrate that very soon a point of what may be termed approximative maximum density is attained, beyond which the effects of pressure become so much smaller and smaller in relation to the force applied, as at last to become almost inappreciable. As a proof of how little the effects of great pressure have been understood, it need only be remembered that until lately it was a commonly received opinion that, owing to the pressure exerted by the column of supernatant water, no animals, even of the lowest type, could possibly exist in the great depths of the ocean; and it was even advanced that any soft muddy deposits would, from the same cause, be consolidated into beds of compact shales, or even rocks. It required, however, only a few deep-sea soundings and casts of the dredge in the depths of the North Atlantic to dispel such illusions, by bringing up abundance of soft and slimy deposits replete with animal life.

The study of geological phenomena does not in any way countenance the idea of such a great body of compressed gases being imprisoned in the interior of our sphere, and, whilst the evidence of great internal heat is totally at variance with such a conclusion, experimental researches upon the compressibility of gases, as far as they have gone, are in direct opposition, since they tend to support the view that the gaseous form of

matter is not compatible with such enormously high pressures, for even by the comparatively low pressures at the experimenter's command, many of the gaseous bodies have already been condensed into the liquid or even solid form.

Having now entered pretty fully into the consideration of the physical character of the interior of the earth, it may be enquired as to whether any light can be thrown upon the chemical nature of the materials which it consists of. It is to be feared, however, that this problem is even more difficult of solution, for excepting the proof afforded by the matter emitted from volcanic orifices—which is in greatest part composed of silicates of the oxides along with some compounds of sulphur, boron, selenium, &c.—we have no means of direct examination whatsoever.

The consideration of the specific gravity of the earth affords some opportunity, however, for speculative enquiry into this subject. As is known, the mean density of the earth's mass is about $5\frac{1}{2}$ times that of water, whilst the average of such parts of its exterior as we are acquainted with is reckoned at only about $2\frac{1}{2}$; it follows, therefore, that the central parts must be infinitely more heavy, in order to account for its mean total density of $5\frac{1}{2}$.

It has been calculated that if the earth was composed of 3 concentric portions of equal thickness and of densities respectively increasing towards the centre in arithmetical progression, we should have—an outer crust, as before stated, of specific gravity $2\frac{1}{2}$; an intermediate zone of about 12; and a central nucleus of about 20 times the density of water; whilst, if we were to imagine more than 3 zones, it would follow that the central nucleus would be found still denser in proportion as more zones are conceived.

As before remarked, the old idea that such great increase in density can be due merely to the effects of superincumbent pressure is not borne out by the results of experiment, and further appears manifestly inadequate, when we also take into account the counteracting effects of the expansion produced by the earth's internal heat; it would follow, therefore, that the substances forming the interior of the earth must in themselves be of a much denser nature than the generality of the bodies which we meet with at its surface.

Of all the elementary bodies recognised by the chemists, it is only some few of the heavy metals which at all approach in density that of either the nucleus or intermediate zone, as already calculated, and consequently it has been inferred that it requires not only the assumption that bodies do become very considerably denser when subjected to pressure, but that there must also be a great accumulation of the heavy metals and their

compounds in the interior of the earth, in order to account for the high mean specific gravity ($5\frac{1}{2}$) of the total mass of the globe.

In reviewing the evidence which has thus been brought forward 'pro et contra' the various hypotheses advanced in reply to the question, 'What does the interior of our globe consist of?' with which we started, the balance of argument appears to be in favour of the older theory, that the earth is a central molten mass surrounded or enclosed by a comparatively thin solid crust or shell; and, further, seems to indicate the probability that its interior, besides consisting mainly of molten silicates, also contains a great accumulation of the heavy metals and their compounds.

Having now summed up the evidence, the verdict is left to be delivered by the jury of our readers.

ON THE USE AND CHOICE OF SPECTACLES.

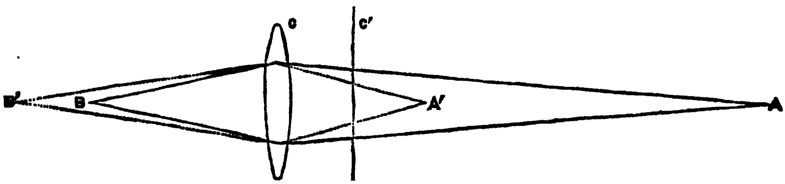
By ROBERT BRUDENELL CARTER, F.R.C.S.

A COMPLETE explanation of all the conditions that may render the use of spectacles desirable, and of all the points that may require to be considered in their selection, would fill a work of very considerable magnitude, and would demand a long period of patient application from the reader. It is the special peculiarity of the eye that its functions fall under the laws of two distinct sciences—optics and physiology—and a considerable degree of proficiency in both is necessary to a full understanding of the way in which each may disturb calculations founded only upon the other. It would, at present, be hopeless to attempt to popularise some of the questions that come continually under the consideration of the ophthalmic surgeon; and I propose to attempt an account only of those defects of sight which are most frequent, and concerning which intelligent people may easily be instructed to choose spectacles for themselves.

The eye, as an optical instrument, bears a very close resemblance to the camera obscura in daily use for taking photographic pictures. In both the essential parts are a dark chamber, a lens to refract the rays of light and bring them to foci, and a screen on which these foci fall and form a picture. This screen, in the eye, is called the retina, and consists of a delicate layer of expanded nerve tissue. How the picture on the retina is made an object of mental perception we do not know; but we do know that there cannot be distinct vision unless this picture is clear and well defined. If we return to the camera, we may soon satisfy ourselves that the clearness of the picture depends upon the maintenance of a certain proportion between the distance of the object, the power of the lens, and the interval between the lens and the screen. If the object be quite distant, the lens must either be less powerful or else a little nearer the screen than when the object is itself brought nearer. The reason of this can be readily made apparent by a simple diagram. If rays of light proceed from the point A (fig. 1), pass through the lens C, and are brought by it to a focus at B, it is manifest that

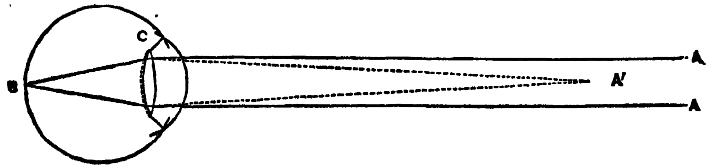
if the point A be brought nearer the lens, as to A′, the rays proceeding from the latter point, being more divergent than those from the former, will be less affected by the lens, and will be united at a point B′, behind B. In order that the rays proceeding from A′ may still be united at B, either the lens C must be made more powerful or it must be moved further from B, as into the position shown by the dotted line C′. In the eye, as in the camera, the point B—that is to say the place of the screen—remains unchanged, and the adjustment required for different dis-

FIG. 1.



tances of the object has to be provided for. In the camera the lens is moved to and fro by rack-work; in the eye there exists an arrangement for increasing the power of the lens by voluntary effort. The eye is represented in diagram in fig. 2, and C is its lens. In a natural eye, this lens is just sufficiently powerful to unite at the retina, B, rays of light that are nearly parallel—such as A A—and that come from a very distant point. In order to unite at B rays that come from the nearer point A′, the lens is rendered more powerful by a voluntary effort; and the effect of this effort, as shown by the dotted line, is to increase the curvature of one

FIG. 2.



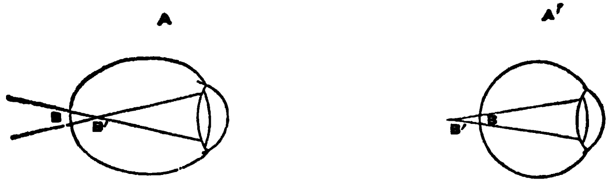
or both of its surfaces. The faculty of thus increasing the power of the lens, so as to see near objects clearly, is called accommodation. The accommodation necessarily has a definite limit; and hence, if we bring print nearer and nearer, it soon arrives at a place where it can no longer be read. The nearest point at which it can be read is called the near point of distinct vision—or simply the near point. The stronger the accommodation, the nearer will this near point be to the eye. As life advances, the accommodation diminishes; partly because the lens itself becomes less yielding, partly—perhaps, because the

strength of the muscle of accommodation declines; and the result is that, from youth onwards, the near point constantly recedes farther and farther from the eye. When the sight is perfect, it is usual to test the place of the near point with Brilliant type. At eleven years of age, this can usually be read as close as at three inches from the eye. At fifty years of age, it would scarcely be read nearer than at eighteen inches; and at sixty, scarcely nearer than at two feet. And, as the light falling upon the eye from any surface diminishes as the square of the distance increases, it follows that a pupil of the same dimensions would receive from a printed character, at eighteen inches, only one thirty-sixth as much light as from the same character at three inches. At two feet, it would receive only one sixty-fourth as much as at three inches. And this explains the practical inconvenience arising from the diminished accommodation of advancing life. In time, the near point comes to be so far off, that we do not receive from the object light enough to see it distinctly. Dr. Kitchener, writing in days before people had gas in their houses and many kinds of brilliant light at command, said that the first sign of the need of spectacles was a tendency to bless the man who invented snuffers. The same rule still applies; and men between forty and fifty will still be found to seek the best artificial light, before their eyes have changed so much that it becomes inconvenient to hold the object at the required distance. The change, as has been said, is gradual and steadily progressive; and it is therefore impossible to fix upon any natural beginning of what is called "aged sight," or, technically, "presbyopia." For the sake of convenience, it is necessary to have some definition of the meaning of the term; and Professor Donders suggests that a person may be called presbyopic when, in consequence of gradual failure of the accommodation, the near point is farther than eight inches from the eye By that time, inconvenience will usually be felt in attempting to read, or to do fine work by artificial light; and then the time for spectacles has arrived. We have seen already that the aim of the function of accommodation is to increase the power of the natural lens of the eye. When this can no longer be sufficiently increased, it may be added to. To place an artificial lens outside the eye adds to the power of the whole optical apparatus, and removes the inconveniences incidental to failure of accommodation. This is the ordinary purpose of spectacles when they are first required in advancing life, or from the forty-fifth to the fiftieth year.

The natural eye, however, in which the nearly parallel rays from distant objects are united upon the retina without an effort, and in which the accommodation is only called into play for near objects, forms a standard that may be departed from

in two opposite directions. If we imagine this natural eye to be nearly spherical, we shall see that, in an eye like A, fig. 3, which is more or less egg-shaped, and longer than a sphere, the rays of light from distant objects, instead of meeting at B, on the retina, would meet at B′ in front of it. On the other hand, in an eye like A′, that is flattened, or too short from back to front, the rays would reach B before they were united; and if the coats of the eye were transparent, would pass through them, and meet at B′ behind the retina. In neither case would there be distinct vision. If we now turn back to figure 1, we see that there, by bringing the point A nearer the eye, to A′, the focus B is put farther back to B′. This is just what we want to do for the eye A in fig. 3. Its focus must be put back until it falls upon the retina. To do this, we bring the object nearer the eye, and as soon as it reaches a certain point, the object becomes clearly visible. Such an eye is said to be short-sighted, or near-sighted, and nearness of sight is defined by the distance

FIG. 3.



of the *farthest* point of distinct vision, just as presbyopia is defined by the *nearest* point of distinct vision. The other defect, the flat eye, is technically called hypermetropia, and there is no good English name for it. In it (A′, fig. 3) it is manifest that the lens requires to be made more powerful; and hence a certain amount of accommodation is called into play, even for distant objects, and cannot be wholly relaxed. A natural eye has its accommodation wholly relaxed when looking at distant objects, and hence wholly in reserve for near ones. A flat eye is perhaps using one-half of its accommodation always, and has only the other half in reserve for near objects. When looking at near objects, perhaps all of this remaining half is employed, and hence the eye soon suffers pain and inconvenience from over-fatigue.

We may still further elucidate these several conditions by simple diagrams. The natural eye, when placed at the point A,

A ———— N . . . . N′ ———— F →

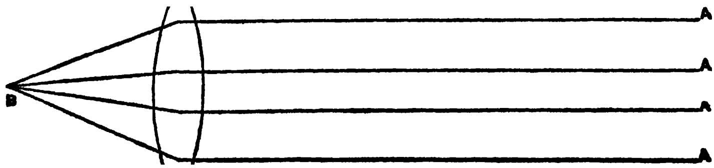
looking along the line towards its far point F, has that far point at an infinite distance, as at a fixed star, and its distant

vision is only limited by failure of light. Its near point, originally very near the eye, as at N, gradually recedes along the dotted portion to N′, and the eye* has always the range of view from N or N′ to F. The short-sighted or myopic eye has

A′———N″. . . . . $N_{\prime\prime}$ F′———

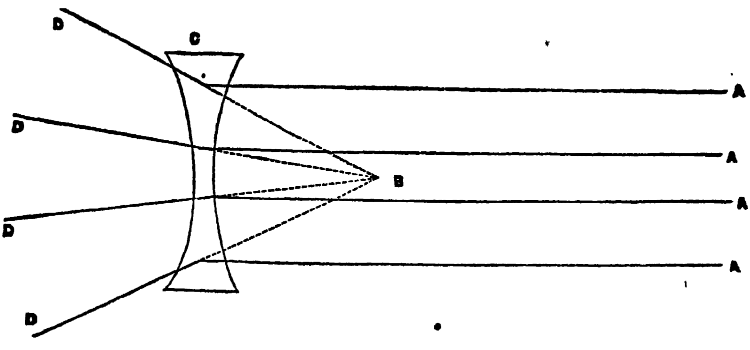
its far point near at hand, as at F′, and its near point still nearer, as at N″. It has only the range of vision between N″ and F′, and if it should become presbyopic, this small range is still more diminished, by N″ receding to $N_{\prime\prime}$.

FIG. 4.



In order to counteract optical defects, we make use of lenses, most commonly of what are called spherical lenses. These, when convex, possess the power of bringing rays of light to a focus at some given distance. Thus, in fig. 4 the convex lens C

FIG 5.



receives parallel rays of light A A, and unites them in a focus at B, which is called the focal point, or principal focus of C; and the distance from C to B is called the principal focal length. If this distance be six inches, we call C a six-inch lens. If the lens be concave, as in fig. 5, its effect is precisely the reverse;

and it causes the rays of light to diverge, or spread out towards D, as if they came from B, which also is called the principal focus, and the distance C B the focal length. The reader who carefully considers these diagrams will see that, if we place before a short-sighted eye a concave lens of six inches focal length, it will make the rays from distant objects come to the eye in the same state or direction as if they came from an object exactly six inches distant. They will then be united upon the retina, and clear vision of the distant objects will be obtained. On the other hand, if we place before a presbyopic eye a convex lens of six inches focal length, we cause the rays of light from an object only six inches distant to strike the eye as if they came from far distance, and the object will be seen distinctly.

Since people with natural eyes, in order to be presbyopic, have only to live to be forty-five or fifty years of age, the spectacles that they will then require are matters about which it concerns everybody to be informed. There are old prejudices against beginning glasses "too early," against using them "too strong," and against changing to a higher power too frequently. The object of glasses is to enable the eyes to work comfortably, without fatigue; and the glasses should always be strong enough to effect this object, and should be used as soon as inconvenience is felt. On this point it is difficult or impossible to lay down any rule that will not be subject to frequent exceptions; but when the sight has been previously good, the first indications of the need for glasses will be a little mistiness of fine print by candle light, a difficulty of distinguishing between somewhat similar letters, such as *m* and *n*, and a tendency to draw the candle or lamp nearer, or even to hold it between the eyes and the book. Glasses having a focal length of sixty inches will then usually suffice for a time, and the ascent to higher powers should be gradual. The first spectacles should at first only be used for reading in the evening; and, when no longer sufficient, they may be superseded for evening work by others, and the first pair reserved for reading by daylight, or for writing, which requires less critical vision, more especially if care be taken to use ink that flows black from the pen. The objection to the higher powers is, that convex lenses contract the range of vision by bringing the far point to their own focal distance. If we wear lenses of twelve-inch focal distance, we cannot, through them, see clearly at any point beyond that distance. And if the powers be too high, the focal distances too short, and the range of vision too much curtailed, the muscles of the eyes are strained in order to keep them both directed to a point within this range, and the circulation is impeded by the bent neck and stooping posture that are required in order to bring the head near to the work. Moreover,

any rapidly recurring need to change the spectacles does not speak only of presbyopia, but gives warning of the approach of disease, and of the need to consult a surgeon. As an approximative standard, Professor Donders gives the following table of the glasses that would be required on account of presbyopia, by eyes originally natural, at different periods of life. If this scale were much departed from, it would be fair to presume that some defect besides presbyopia was present :—

Age	Focal Length of the Spectacles, in Inches	Reading Distance with the foregoing, in Inches	Age	Focal Length of the Spectacles, in Inches	Reading Distance with the foregoing, in Inches
48	60	14	60	16	13
50	40	14	62	12	13
55	28	14	65	10	12
58	20	13	70	7½	10

In myopia, or short-sight, we have to deal with much more complicated conditions; and it may be laid down as a general rule that all myopic eyes are more or less diseased eyes, and are liable, by reason of their short-sightedness, to various changes that are slowly destructive to vision. Short-sighted eyes are, as has been said, oval in shape, or too long from front to back; and the necessity to keep them fixed on a near object tends continually to increase the malformation, and hence to increase the shortness of sight. The eyeballs are practically bags filled with fluid, and when they are strongly drawn inwards, by muscles that are inserted near the front of the inner surface of each eyeball, there is a necessary tendency to a corresponding degree of bulging at the back; and this bulging, if often repeated, has a tendency to become permanent, and so to increase the original defect of shape. Moreover, the only portion of the eyeball that can be thus stretched without grave injury is the outer or protective coat; and the delicate membranes within this coat, especially the retina itself, are apt to be seriously or even irreparably damaged. There is a prevailing belief that short-sighted eyes are essentially good and sound eyes; and than this there can be no more mischievous error. The fact is, that short-sighted people can often discern very small objects readily, simply because they bring them so near the eye as to get plenty of light from them. They also do not require reading spectacles on account of presbyopia, either not at all, or not so early as other people; and these two peculiarities have given rise to the popular notion. It cannot be too universally known that short sight tends to increase; and that, if it increase at all rapidly, it tends also to destructive changes.

For young people who are short-sighted the use of spectacles should be considered imperative; and, if the far point be not nearer the eyes than ten inches, these spectacles should generally neutralise the short sight completely. For this purpose their focal length in inches should be equal to the distance of the far point. If this point be nearer than ten inches, the eyes will generally require special advice and management. But in any case it must be remembered that the object of the spectacles is not to enable the patient to see *better*, but to see *at a greater distance*; so that the book, or the writing, or the work, may be kept away from the eye, and the injurious effects of looking at a near point may be prevented. When short sight is increasing, there will be a constant tendency, in spite of spectacles, to bring the book *up*, and to bring the head *down*; and this tendency must be fought against as the worst of all temptations. If yielded to, it strains the eyeballs, contracts the chest, overfills the head and eyes with blood, produces increase of the defect, and often eventual blindness. In order to keep the head well away, it is absolutely necessary to have plenty of light; and young people and students should pay special attention to this matter. Reading by fire-light, or in a window by the waning light of evening, should be strictly prohibited; and attention should be given to the quality of artificial light. For lighting up a room, there is perhaps no light superior to that of a paraffine lamp with two parallel wicks; * and the best table light for reading or writing is afforded by the well-known lamp made by Stobwasser of Berlin, and commonly known as the "Queen's Reading Lamp." It should have a green shade, and should be just so much lowered that this shade protects the eyes, when they are raised from time to time, from the direct glare of the flame.

The flat or hypermetropic eye is a great source of trouble to its possessor; and until quite recently this trouble was incurable by any known means. As has been explained, the flat eye is never at rest. It is always using some of its accommodation, often using all. Hence it becomes speedily fatigued, and, with fatigue, the accommodation relaxes, and vision becomes dim. The hypermetropic person will begin to read or to write with ease. After a short time the eyes feel strained and tired, and the letters become misty. The patient looks away from his work, shuts his eyes, presses the hand upon the closed lids with a very peculiar gesture, and makes a fresh start. The second period of work is shorter than the first, and the third shorter than the second. This affection was long known as "asthenopia" or "weak sight," and as its cause was

* Patented by Hinks of Birmingham.

not suspected, no remedy for it was known. Sufferers were advised to change their mode of life, to give up reading and writing, and handicrafts requiring accurate vision, and to turn sheep farmers in the colonies. It was reserved for Professor Donders, of Utrecht, to find out the cause of the malady; and to know the cause was to know the cure. The necessity to strain the accommodation is removed by convex spectacles, and their use restores the sufferer to good vision and perfect comfort. They should be the strongest that can be borne for distant objects; and, when first used, will usually require to be strengthened after a time, perhaps more than once, if any of the old symptoms return. They must be worn always; and only laid aside at bed-time.

Before leaving hypermetropia, it is as well to mention that it is the ordinary cause of squint; although space does not allow any explanation of its influence.

The existence of the three conditions mentioned may be known by the following tests. In presbyopia, we have an increasing necessity to remove a book farther and farther from the eyes, and convex spectacles allow it to be brought back to a convenient distance. In myopia, or short sight, distant vision is improved by weak concave glasses. In hypermetropia, it is improved, or at all events not made worse, by weak convex glasses.

Besides the above, which may be called simple defects, there are others of a more complicated character. In "astigmatism" the surface of the eye is differently curved in different directions, and horizontal lines are more plainly seen than vertical ones, or *vice versâ*. Sometimes the surfaces are altogether irregular, sometimes the two eyes are dissimilar. Dr. Scheffler of Brunswick, whose treatise on ocular defects I have lately translated, states that there are 729 *possible* defects of each eye singly; and hence more than half a million of possible combinations in the pair. These step beyond the boundaries of popular science.

In the same work Dr. Scheffler has fully described a new form of spectacles of his invention, to which he has given the name of "orthoscopic spectacles." They are made by cutting the glasses out of the margin of a larger glass, and are adapted to relieve the feeling of fatigue, or "strain," which spectacles often produce. For presbyopia of moderate degrees, not requiring glasses of higher power than eighteen inches focal length, I think they are likely to be extremely valuable.

It still remains to say a few words about the materials of which spectacle lenses are made, and about the frames in which they are set.

The lenses should be of the best crown glass, free from all

The lenses should be of the best crown glass, free from all spots, flaws, streaks, or air-bubbles, and perfectly colourless. Improvements of manufacture have made this glass far better than Brazilian pebbles, once greatly in repute, but which, unless cut exactly at right angles to the axis of the original crystal, are apt to be very disturbing to vision.

The frames should be of blue steel, light, strong, and perfectly fitted to the wearer. The centre of each ring should be exactly opposite the pupil of its corresponding eye; and the nose-piece of such a height and curvature as to place the lenses in their right position. Concave spectacles should be worn as close to the eyes as possible, convex spectacles a little farther away. When the latter are used on account of presbyopia only, they may even be half way down the nose; and it is convenient to have the rings flattened on the top, so that the wearer may look *through* them at his book, and *over* them at distant objects. Finally, spectacles should be kept perfectly clean, never thrown about carelessly, nor pocketed without their case. The lenses should be wiped, when necessary, with a piece of clean soft wash-leather; and replaced if scratched or clouded. They are often essential auxiliaries to vision; and they should be cared for like the eyes themselves.

THE USE OF THE SPECTROSCOPE IN ASTRONOMICAL OBSERVATION.

By RICHARD A. PROCTOR, B.A., F.R.A.S.
Author of "Saturn and its System," "Half-Hours with the Telescope," &c. &c.

[PLATES XLII. AND XLIII.]

THE manner in which the spectroscope has taken its place among astronomical instruments presents a remarkable contrast to that in which the telescope was received. In the case of the latter instrument all the advantages derivable from the new invention were at once recognised, yet the instrument made its way but slowly into use, and the various appliances by which it is rendered available as a means of advancing the science of astronomy were devised at periods separated by long intervals. But with the spectroscope the case is wholly different. The power which the instrument gives the astronomer was at first far from being obvious. That it was a wonderful means of research was indeed clear; but certainly he would have been a bold reasoner who would have ventured ten years ago to predict that the spectroscope would take up the position it now occupies as an aid to astronomical research. Already it has resolved problems which would have been deemed altogether insoluble ten years ago; and it has answered questions which, at first sight, would seem to lie out of its proper range of action—questions, for example, affecting the motion as well as those affecting the constitution of the celestial orbs.

Undoubtedly the sudden growth of the new analysis is mainly due to the good fortune which has placed its application in the hands of a physicist possessing a combination of qualities rarely met with, but which were absolutely necessary in the case of the pioneer of the new line of scientific advance. Extraordinary skill in observation and manipulation, an intimate acquaintance with optical and chemical laws, extreme caution in the interpretation of observed phenomena, and unremitting perseverance and patience in conducting experiments tending

to elucidate or confirm his observations—such were some of the qualities which were required in the physicist who was to place the science of spectral analysis (as applied to astronomy) upon a sound basis. When we compare the vague and unsatisfactory results obtained by other observers with those which Mr. Huggins has set before us, and when we note also the influence which his researches have had in showing the way to less experienced observers, and enabling them to make important discoveries, we begin to understand the full value of his labours. We would say to those whom we are about to invite to a new and fertile field of labour, Let your first task be to examine the work which Mr. Huggins has done; observe the skill with which the mode of observation is selected; note how each result is weighed and tested before it is admitted; and, in fine,

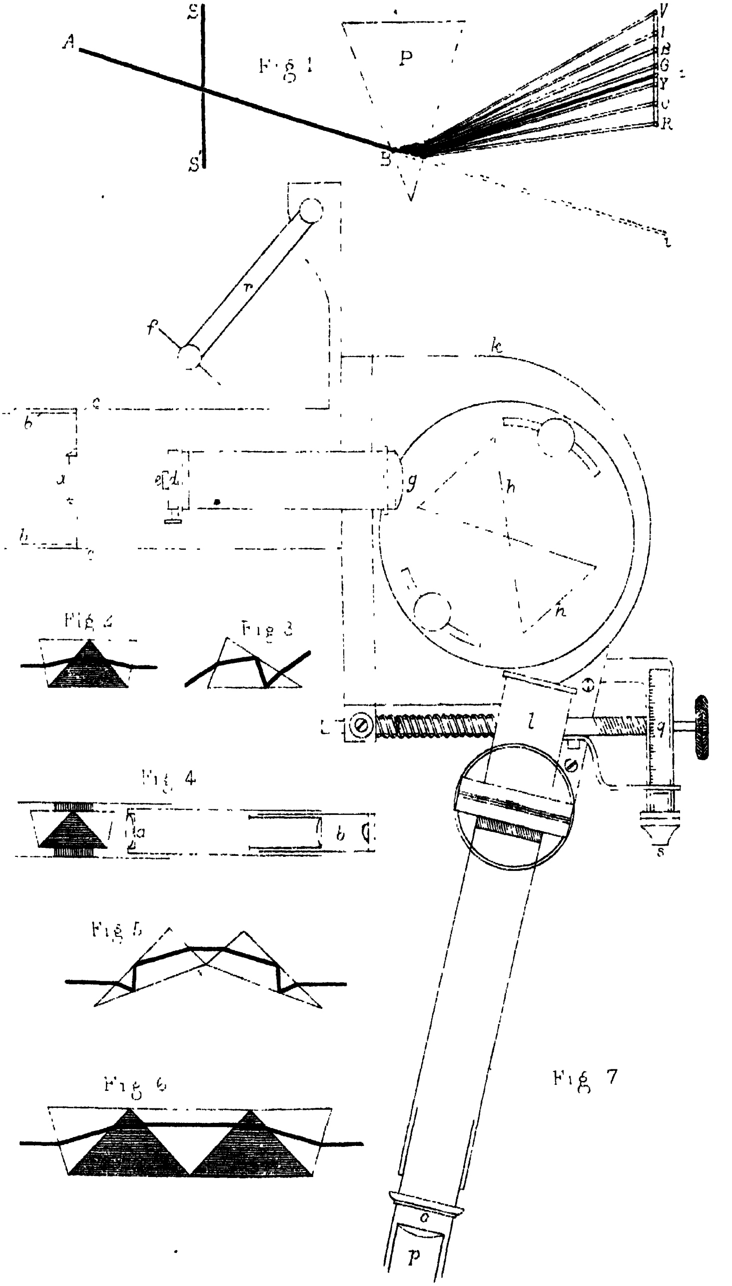
Vos exemplaria Græca
Nocturnâ versate manu versate diurnâ.

The principles on which spectrum analysis depends are few and simple; nor are the contrivances by which it is adapted to astronomical research difficult of comprehension.

The simple prismatic analysis of light is exhibited in fig. 1. A beam of sun-light, AB,* passing into a darkened room through an aperture in a screen SS′ would, if not interfered with, form a small spot of light at *i*, in the same straight line with AB. Now, suppose a prism P to be interposed. If sun-light were homogeneous, the laws of optics tell us that the beam would be simply diverted from its course, so that the spot of light would fall as at *i′*, the dark line indicating the path of the ray. But, instead of this, a streak of light, as VR, is seen (VR is much exaggerated in length) coloured like the rainbow, red at its lower end (when the prism is situated as shown), and violet at its upper end—the colours succeeding each other in the order red, orange, yellow, green, blue, indigo, and violet. It is the analysis of this spectrum which forms the mode of research recently rendered available to the astronomer. The examination of the dark lines which appear in the spectrum when the sun is the source of light is called solar spectroscopy, the determination of the position of the lines seen in the spectra of

* I have thought it best not to confuse this account by considering the size of the source of light, or by exhibiting the course of a slightly divergent pencil. Experience shows that the beginner is apt to be confused by such a mode of describing the formation of the spectrum. He confounds the dispersing effect of the prism with such effects as lenses produce on the convergency or divergency of pencils, because he sees the same mode of illustration used in each case. As the space at my disposal only permits a few words in reference to the formation of the spectrum, it was the more necessary that no mistake of this sort should arise.

Plate XLII



W West lith

stars is called stellar spectroscopy; and, in fine, the determination of the nature of the spectra of celestial objects is the aim of all the various contrivances made use of in the application of spectral analysis to astronomy.

The first point to be considered is the formation of a pure spectrum. From fig. 1 we see that a light-pencil, which would form a spot, *i*, of definite magnitude, if not interfered with, would form a series of images along the streak RV. The figure shows the formation of one red image, one orange image, and so on. But in reality there would be an infinite number of images along RV; and although the beauty of the spectrum would not be at all affected by this circumstance, it would be impossible to detect the absence of rays of definite refrangibilities, simply because the images formed by rays of neighbouring refrangibilities would conceal the want. The spectrum, however beautiful, would be in fact impure in the sense in which the spectroscopist uses the term.

Therefore, when the object to be observed has a sensible magnitude, it is necessary to let its light pass through a narrow slit parallel to the refracting edge of the prism. The same is true whether the object itself is observed, or the image of the object obtained by means of a lens, or by any combination of lenses. But, of course, any optical contrivance by which the apparent dimensions of an object can be reduced, is serviceable to the end we are considering.

Next, as to the mode by which the spectrum is viewed.

An eye placed so as to receive any of the light forming the spectrum is sensible of the nature of the particular part of the spectrum to which that light belongs. The eye may be aided by a telescope, or by an eye-piece, or may be used without such aid; but for delicate researches a telescope is always used for the examination of the spectrum.

Beginning with the simplest form of observation—suppose an observer wished to view the spectrum of a star with the prism P. Here no slit or darkened room would be necessary. But the observer would meet with a difficulty. Supposing the star to be towards A (fig. 1), and the prism held as shown, the observer would have to look from *i'* towards B, which is not the direction in which the star lies.

To obviate this inconvenience in the case of a simple observation of this sort, direct-vision prisms have been devised. The property on which they are founded is that called the "irrationality of dispersion":—

In fig. 1 the angle between the emergent ray from B to *i'* and the line *i*A is called the deviation of the ray. In the position of the prism shown in the figure the deviation for this ray has its minimum value; and if the ray is supposed to be

one of mean refrangibility, the angle between BI and BI′ affords a measure of the prism's power in causing deviation. On the other hand, the length of the spectrum VR affords a measure of the prism's dispersive power. If dispersion bore a constant proportion to deviation, it is clear that we could not by any combination of prisms see a spectrum when looking straight towards a star, because the means used to make the deviation vanish would also do away with the dispersion. But as this proportion has been found not to hold, we are enabled to overcome the difficulty. It has been found that flint glass gives a spectrum of much greater length for a given deviation of mean rays than a prism of crown glass. If, then, we correct the deviation caused by a flint-glass prism by means of the deviation caused by one or more crown-glass prisms, there will still remain an uncorrected dispersion; in other words, a spectrum will still be visible. This is what is done in the compound prism of Amici (shown in fig. 2), in which a flint prism is placed between two crown-glass ones. Here the rays of mean refrangibility suffer no deviation, so that it is possible to look directly at a luminous object through the compound prism; but a spectrum is seen because the dispersion produced by the flint prism in one direction is greater than the dispersion produced by the two crown-glass prisms in the other.

Fig. 3 represents another form of direct-vision prism, in which the light undergoes three internal reflections before emerging. This contrivance was devised by Mr. Alexander Herschel for the observation of meteors. The construction involves practical difficulties, as every face of the prism is brought into action, and great care is therefore required in the preparation of the prism. These difficulties were successfully overcome by Mr. Browning, who takes up *con amore* all matters connected with spectroscopy. An instrument formed on this plan, or by the combination of two such prisms, as shown in fig. 5, is called a Herschel-Browning direct-vision spectroscope.

It is worthy of notice that a simple prism, or better, any direct-vision prism, will serve to exhibit the dark lines in the spectra of the stars if only a Huyghenian eye-piece be made use of in examining the spectrum. Nothing, perhaps, is more remarkable than the circumstance, that whereas Lord Rosse's telescope does not suffice to give any indications whatever of the fact that the nearest fixed star has appreciable dimensions, a hand-spectroscope, which can be obtained for fewer pence than the great reflector cost pounds, will exhibit those dark lines in the stellar spectra which enable us to determine the physical constitution of these distant orbs.

In fig. 4 a mode of using a direct-vision prism in combination with a small achromatic telescope is shown. The instrument

was contrived by Mr. Huggins for the purpose of observing the spectra of meteors and their trains. The achromatic object-glass *a* is an inch and one-fifth in diameter, and has a focal length of ten inches. The eye-piece *b* consists of two plano-convex lenses. The magnifying power of the eye-piece can be varied within certain limits by changing the distance between the two lenses. The apparatus is used without a slit, so that it is only applicable to objects like stars or meteors, or the thin cusps of the lunar crescent, which have no perceptible breadth. In observing the lunar cusps, their length must of course be brought at right angles to the direction in which the spectrum is formed, and similarly with meteor-trains. Fraunhofer's lines have been seen by Mr. Huggins in the spectrum of the moon when a very narrow crescent. He also saw the bright lines belonging to several metals, in the spectra of the Crystal Palace fireworks, three miles from the place of observation. The dark lines of the stellar spectra are well shown by means of this instrument; but as the spectrum of a star is a bright line, it is well to give a small breadth to the spectrum "by means of a cylindrical lens fitted in a little cap which slips over the eye-lens and is placed next to the eye." The spectrum of the great nebula in Orion shows two bright lines when observed with this instrument; so that here we have another instance of an instrument of small price which affords a satisfactory answer to a question which it had been found hopeless to attack by the largest telescopes man could construct.

In the expeditions sent out to view the great eclipse of August 1868, four of these instruments, made by Mr. Browning, were sent out by the Royal Society to India.

The field of view of the hand-spectroscope has a diameter of about seven degrees, according to the arrangement exhibited in fig. 4. Mr. Browning has suggested arrangements—presented in fig. 8—by which the observation of moving bodies, such as meteors, is rendered much easier, on account of the great increase in the field of view. In fig. 8, AA represents a direct-vision spectroscope, B a plano-convex cylindrical lens, C a double concave lens of much greater focal length. The line 1, 2, 3, represents the path of a meteor, and the dotted lines from the points 1, 2, 3, are seen to be so acted upon by the lenses as to produce an almost stationary image. With this instrument Mr. Browning found it easy to obtain the spectra of balls shot from a Roman candle placed but a few yards from the instrument. Although the angular velocity of the balls was of course very great, the characteristic lines of baryta, strontia, &c., were clearly exhibited.

Appliances such as these may, of course, be equally well adapted to the Herschel-Browning direct-vision spectroscope,

either single as in fig. 3, or double as in fig. 5, or to a compound prism of five pieces, as shown in fig. 6.

But the use of small instruments such as those above described, must be looked upon merely as preliminary to the thorough investigation of the spectra of celestial objects by means of spectroscopes attached to telescopes of considerable power. It is only by the use of such instruments that the observer can hope to make important additions to our knowledge of celestial physics.

In fig. 7 is pictured the kind of spectroscope made use of by Mr. Huggins in his long series of researches.

It will be understood that the large telescope to which the spectroscope is attached serves the purpose of light-gatherer. The spectroscopes we have hitherto described have had to be limited in their dispersive action, in order that the light received from a star might not be altogether lost to the eye through dispersal. But now the image of a star formed by a large object glass (or mirror) is to be made the subject of observation, and therefore the spectroscope may exercise a much greater dispersive power. In fig. 7, *c* represents the tube of the spectroscope which is inserted into the eye-tube of the large telescope in place of the ordinary eye-piece. (The tube *c* and the inner sliding tube *b*, are longer than shown.) The slit of the spectroscope is at *d*, and the spectroscope is so placed that *d* is exactly at the focus of the object-glass (or mirror). The sliding-tube *b* carries a cylindrical plano-convex lens, the effect of which is to change the image of a star from a point into a line. It is clear that the linear image thus formed at *d* will be at right angles to the axis of the cylinder. For, in a plane passing through the axis of the object-glass, and also through that of the cylinder, the rays will converge to the focus of the object-glass, but in a plane at right angles to this (through the axis of the object-glass) the rays will converge to a focus nearer the object-glass, owing to the convexity of the cylindrical lens, and these rays will pass at a sensible distance from the focus of the object-glass. This linear image must fall upon the slit, which, therefore, must be placed at right angles to the axis of the cylinder.* In Mr. Huggins' instrument the length of the image was one-tenth of an inch, and the spectrum formed by the light from this image had a corresponding width; but, as seen by the small telescope, it appeared about half an inch wide, owing to

* A little consideration will show that there is another linear image parallel to the axis of the cylinder, at the second focus named above—that is, nearer the object-glass. Mr. Huggins tried the effect of causing this image to fall on the slit, but the spectrum was not so good as by the other method.

Plate XLIII

1

2

3

Fig 8

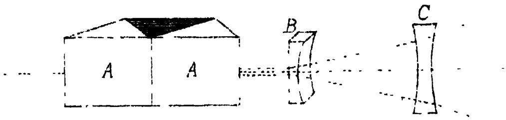


Fig 9

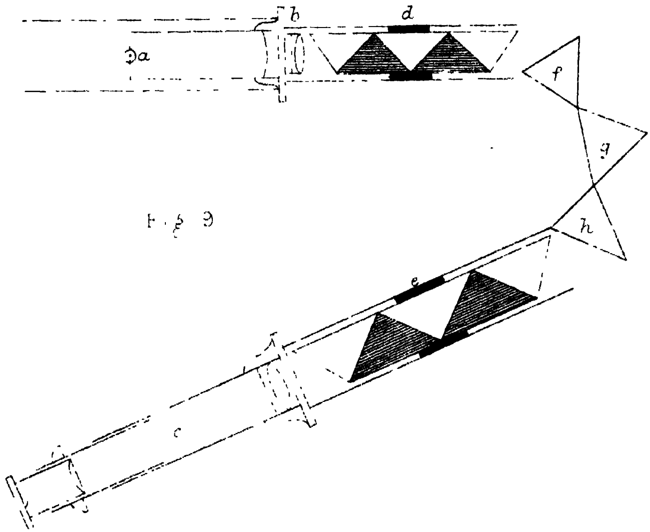
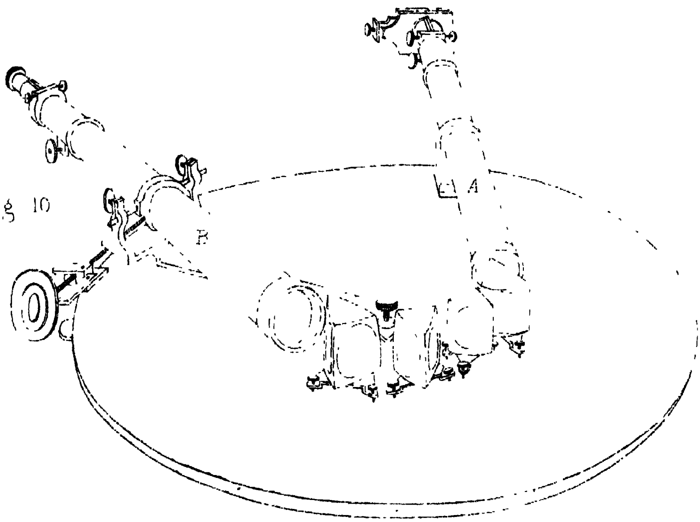


Fig 10



the magnifying power of this telescope. Over one half of the slit *d* is placed a right-angled prism *e*, for the purpose of reflecting the light received from the mirror *f*, through the slit, and thus comparing the spectrum of the star or other celestial object under examination with that of light from any other source. Behind the slit is placed a collimating lens *g*, at a distance equal to its focal length. The diameter of the lens is such that it receives the whole of the light diverging from the linear image when the latter is brought exactly within the jaws of the slit. The dispersing portion of the spectroscope consists of the two prisms *h*, *h*. The refracting angle of these prisms will be different according to the purposes which the instrument is meant to subserve. In his researches on stars Mr. Huggins employed a spectroscope having two prisms (made by T. Ross), each of 60 degrees; but for many of his most important researches he found it advantageous to employ a spectrum-apparatus constructed by Mr. Browning, in which one of the prisms had an angle of 35 degrees, the other an angle of 45 degrees. The spectrum is viewed through a small telescope *l*, having an adjustment for level at *m*. At the focus of the object-glass of this telescope are fixed two wires at right angles to each other. These are viewed together with the spectrum by the positive eye-piece *p*. The telescope is carried by a micrometer-screw *q*, the centre of motion being so situated that the rays forming any part of the spectrum pass centrically through the object-glass when the telescope is so placed as to receive such rays.

It will be seen from this description that there are two ways in which the position of any line in the spectrum of a star can be determined. Either it may be compared with the bright lines seen in the spectra of different metallic elements, these spectra being brought into comparison with the star's spectrum by means of the mirror *f*; or else, when any line in the star's spectrum has been identified with some solar line, we may first bring that line into coincidence with the cross-wire in the focus of the object-glass, and note the reading of the micrometer-screw; then move the telescope until the line whose position we require to determine is brought to the cross-wire, and again note the reading of the micrometer-screw. The difference between this and the former reading indicates the distance between the two lines.

Of course other modes of measuring the arc through which the telescope has moved are available. Into these we need not enter, as every observer will be familiar with the contrivances suitable for such a purpose.

It must be noted that a spectrum mapped out in this way will not agree with the spectrum of the same object similarly mapped out by means of another instrument, because different

spectroscopes have not only different dispersive power, but give spectra in which the distances between the fixed lines are not proportional *inter se.* Let not the observer, therefore, fall into the error of imagining (as we believe a well-known foreign spectroscopist did) that the lines of a star's spectrum have changed their place, when the apparent difference is in reality due to the "irrationality of dispersion." In fact, every observer must thoroughly master the peculiarities of his own spectroscope before pretending to discuss the results obtained by means of it. He should know the exact positions of all the principal lines and groups of lines shown by it, so that when he has observed any line in a star's spectrum he may know approximately the true position of that line with reference to the solar spectrum. He will then know what are the substances whose spectra should be compared with that of the star, in order to ascertain if this line coincide with one of those belonging to known elements.

It need hardly be said that, as the image of the star is to be kept exactly within the slit, it is an absolute necessity that the telescope should be an equatorial, accurately driven by clock-work.

It is also necessary that the telescope should be one of large aperture, as otherwise none but the brightest stars could be examined with powerfully dispersive apparatus. On this account it is probable that reflectors will be largely used by spectroscopists, since achromatic refractors of suitable aperture are so much more expensive than reflectors of corresponding illuminating power. It happens, fortunately, that Mr. Browning, who has paid so much attention to the improvement of reflecting telescopes, appreciates also most thoroughly the position which spectroscopic analysis is about to take up as a means of astronomical research. The spectroscopes he constructs for use with the telescope correspond in all essential respects with the form above described.

For special purposes great dispersive power may be required in the observation of stellar spectra. Fig. 9 shows an arrangement by which Mr. Huggins has obtained great dispersion without an amount of deviation which would cause the pencils, after passing through the prisms, to cross those from the collimator. In this instrument *a* is an adjustable slit, *b* an achromatic collimator, *c* the telescope with which the spectrum is observed, *d* and *e* are direct-vision prisms, *f*, *g*, and *h* simple prisms. The total dispersive power of this instrument is equivalent to that from six and a half prisms of 60 degrees; or, in other words, corresponds to what would be given by a set of simple prisms which would cause a deviation through more than four right angles.

This paper would be incomplete if we did not touch upon the

form of instrument by which the solar spectrum is analysed. Fig. 10 represents the instrument by which Messrs. Kirchhoff and Bunsen carried out the original researches which resulted in the invention of spectroscopic analysis. The light of the sun is caused (by means of a heliostat) to fall upon an adjustable slit, shown at the farther end of the telescope A. The analysing power of the instrument is derived from the four prisms shown in the figure, and B is the telescope by which the spectrum is examined. A more powerful instrument on a similar general plan, but with several notable improvements and no less than nine prisms, has been constructed by Mr. Browning for M. Gassiot.

A subject which recently attracted much attention points to a mode of applying the spectroscope which could hardly fail to yield valuable results in the hands of a capable and diligent observer. Mr. Huggins' observation of the spectrum of the variable star T. Coronæ, which suddenly blazed out in 1866, showed that light, which by all other methods of observation would not be separately perceptible, might be rendered cognisable by the spectroscope, for the continuous spectrum of the star was seen to be crossed by bright lines belonging to incandescent hydrogen. The whole light of hydrogen being collected into three fine lines, while that of the star was dispersed over a long spectrum, the former stood out, so to speak, upon the darker background of the continuous spectrum. It occurred to Mr. Lockyer that the property thus exhibited might avail to render the spectrum of the solar prominences perceptible, if these objects are gaseous. As all our readers are aware, the suggestion has been justified by the observations of Jannsens and Lockyer, and a promising means of spectroscopically examining the solar prominences and the neighbouring atmospheric envelope is thus afforded to astronomers. No special apparatus is requisite for the purpose. What is wanted is, that the image of a part of the sun's limb should be brought across the slit at right angles to the slit's length. Then, if the dispersive power of the spectroscope is sufficient, all that is necessary is to sweep the eye-telescope from end to end along the prism (a process which may require more than one adjustment, however); the spectrum of the prominence, if any occupy that part of the sun's limb, will be indicated by the appearance of its characteristic bright lines opposite particular parts of the solar spectrum formed by the light from the limb. It need hardly be said that the telescope must be very accurately driven by the clockwork, and that no spectroscope which has not considerable dispersive power can be useful in work of this sort.

THE BRITISH LION.

BY W. BOYD DAWKINS, M.A., F.R.S.

THE British Lion has generally been considered to be an offspring of the imagination of the heralds, and yet, in reality, it presents as good credentials for its existence as those afforded by the British Wolf, Bear, or Beaver. In the following pages the identity of *Felis spelæa*, the great British feline that inhabited the post-glacial caves, with the existing Lion, will be shown, as well as its ancient range in the Old and New Worlds. But, first of all, a few of the chief opinions held by naturalists as to its affinities will be given.

The first evidence of the discovery of *Felis spelæa* in the district north of the Tyrol, Alps, and Pyrenees is afforded in a plate appended to a paper by Dr. Haine on the dragons of Hungary, and was published in 1672. A fragment of skull from the cave of Schartzfeldt was figured by Leibnitz in 1749, and described in the text as "vera elephantium ossa." It is compared by Sœmmerring with the skulls of Lion and Cave Bear, and also with those of other species of the same genus, and is considered by that eminent naturalist to have been that of the Lion. In 1744, Esper published an account of the mammals found in the margravate of Baireuth, in which he figures an upper feline jaw from Gailenreuth cavern. He obtained also detached teeth and bones. He refers them all to an unknown animal closely akin to the Lion. Rosenmüller, in 1804, states that he is about to publish a work on an unknown fossil animal of the genus Felis, but he adds that its bones differ in some respects from those of the Lion. Dr. Goldfuss, in 1810, published a small work on the environs of Muggendorf, in which a nearly perfect skull is figured and described as *Felis spelæa*—a name which was adopted by Cuvier and by all subsequent naturalists. He considered that it belonged to an extinct species more closely allied to the Panther than to the Lion or Tiger. Drs. Pander and D'Alton state in 1822 that *Felis spelæa* differs specifically from *Felis leo*, and refer to their figures in support of that statement. The figures, however, supply no

points of specific difference. Baron Cuvier, in the second edition of the "Ossements fossiles," published in 1823, does not pronounce a decided opinion on the relation which the animal holds to the large existing members of the genus, because he was unable to make a personal inspection of the type specimens described by Dr. Goldfuss; but he states his belief that its real affinities are neither with the Lion nor the Tiger, but with the Jaguar, giving, as his principal reasons, the gentle curve of the profile and the form of the lower jaw. Our great cave-explorer, Dr. Buckland, was the first to ascribe the spelæan remains to the fossil Tiger, without, however, giving any reasons for his conclusion. His rival, Dr. Schmerling, in his *résumé* of the species of Felis in the caverns of Liége, considered that *Felis spelæa* was allied to the Lion, but of a distinct species. He figures, nevertheless, bones from the same locality as belonging to the existing Lion, but confuses them with the *Felis antiqua* of Cuvier, which was not a Lion but a Panther. MM. De Serres, Dubreuil, and Jeanjean, writing in 1839, insist on the specific distinctness of *Felis spelæa* from the recent Lion, assigning as the principal difference the shortness of the muzzle. They follow Dr. Schmerling in identifying a second species with the latter animal. M. Gervais, in the first edition of his "Paléontologie," published in 1848, regards the animal as a Lion, without assigning any cause for his conclusion. Professor Owen, on the other hand, in 1842, adopted Dr. Buckland's opinion, and terms the animal a spelæan Tiger, although he recognises the lack of evidence sufficient to put its specific identity beyond dispute. He reproduced his views in 1846 in the "British Fossil Mammals." In 1859, however, he published, in the "Philosophical Transactions," a figure of the spelæan skull described by Dr. Goldfuss, with the nasal processes represented as in the Lion. It is clear, therefore, that he recognises the leonine nature of the animal to which it belonged, for his figure shows that characteristic which is of specific value in determining Lion from Tiger. Dr. Falconer is quoted by M. Lartet, in 1864, as holding the view that the animal was identical with the Tiger inhabiting the north of China and region of the Altai, and that it was driven out of Europe "par le développement progressif des sociétés humaines." Nevertheless, in 1858, he enumerated the Cave Lion among the remains from Kent's Hole.

This clash of opinion as to the actual affinities of *Felis spelæa* flows from two causes: the imperfection of the fossil remains, and the non-recognition of the fact that the individuals of living Feline species presented great variations in form and size. In the monograph of the British fossil Felidæ, published by Mr. W. A. Sanford and myself, an attempt has been made to arrive at the truth, by a strict analysis of the sum of the

evidence afforded by the collections of Britain, France, and Germany. In assigning a specific value to differences between Lion and Tiger, we have realised the great amount of variation in size and form within the limits of a species, as insisted upon by our great philosophic naturalist, Mr. Charles Darwin. A minute comparison of the leonine with the tigrine skeletons in London and Oxford has resulted in our being unable to perceive any constant specific differences except the following, and these, moreover, are manifested only by the skulls.

In the Lion the frontal processes of the maxillaries extend at least as far back as a transverse line passing through the naso-frontal suture; their apices are pointed. The inner bounding line of the nasal aperture, viewed in front, forms an even curve. The frontal ends of the nasal bones are flat. In the frontal bones the inter-orbital space is flatter and wider than in the Tiger. The temporal length of the frontals is smaller, and consequently, the post-orbital process is placed farther back, and the forward extension of the sagittal crest is less. The comparatively shorter space between the posterior palatal foramen and the orbital edge of the palate, when viewed in relation to the basal length of the skull, is also to be reckoned characteristic. The ramal process is always more or less developed on the inferior border of the lower jaw, and invariably causes the latter to pass below a plane extending from the angle to the symphysis.

In the Tiger the frontal processes of the maxillary bones never extend so far back as a transverse line passing through the naso-frontal suture; their apices are truncated. The internal bounding line of the nasal aperture, when viewed in front, presents a double curvature. The frontal portions of the nasals are bent downwards, so as to form a median depression at their symphysis. The post-orbital processes have a larger frontal development, and cause the inter-orbital surface to be more concave and narrower than in the Lion. The greater temporal length of the frontals causes the long-waisted appearance, and the greater development of the sagittal crest in the adult. The posterior palatal foramen is farther removed from the orbital edge of the palate relatively to the basal length of the skull. The ramal process is invariably absent from the lower jaw. The bones of the trunk and the extremities present such variations in Lion and Tiger, that they offer no point of specific value.

What, then, was the relation which the great Felis of the British caves bore to these two animals? The two nearly perfect skulls from the Mendip caves and the one from Sundwig, in the British Museum, afford the materials for the answer of this question. In all the characteristic points of difference above

noted, between the Lion and Tiger, *Felis spelæa* is more leonine in character than the recent Lion, and more divergent from the tigrine form. Were the three animals placed in serial order, *Felis leo* would occupy the middle place, the points of difference between Lion and Tiger being exaggerated in *Felis spelæa*. While it is undoubtedly true that the animal was on the whole larger and stronger than the existing Lion, some individuals were even smaller than the average Lions of the present day. There is not one solitary character by which the animal can be distinguished from the living Lion; its specific identity, therefore, with the latter animal must be admitted. And thus we are compelled to hold the belief that the Cave Lion, which preyed upon the Mammoth, woolly Rhinoceros, and Musk-sheep in Great Britain, is a mere geographical variety of the great carnivore that is found alike in the tropical parts of Asia and throughout the whole of Africa.

We will now pass on to the consideration of its range in Britain. It has not yet been found in Scotland, Northumberland, Cumberland, or Westmoreland. In the North Riding of Yorkshire its teeth were obtained from the bone cave of Kirby Moorside, along with the remains of the Cave Hyæna and Wolf. Two canines, a metacarpal, and a calcaneum were found in the Hyæna-den of Kirkdale, along with relics of the leptorhine Rhinoceros of Owen, the Mammoth, Bison, Reindeer, and others. In the river deposit of Bielbecks, in the same county, a very fine series of remains of Bear, Bison, Wolf, and Cave Lion were disinterred by the Rev. W. Vernon; those of the latter consisting of a fragment of maxillary, both rami of the lower jaw, the ulna, radius, femur, and metatarsals, all of which belonged to one individual. The numerous caves in the mountain limestone of Lancashire and Derbyshire, strange to say, have not furnished a single fragment that can be attributed to the Lion, although they have been diligently explored at various times; nor in the Midland Counties has the animal been discovered as far south as the meridian of Oxford.

In the Eastern Counties it is very rare. The post-glacial gravels of Barnwell have yielded a lower jaw that is preserved in the natural history collection in Cambridge, and a femur that is now in the British Museum. In Suffolk its remains have been found in a bed of gravel at Ipswich, along with those of the Roe-deer, Bison, Irish Elk, tichorhine Rhinoceros, grizzly Bear, and others. In North Essex, the energetic collector Mr. John Brown, of Stanway, obtained a humerus from Clacton, as well as other remains, quoted by Professor Owen, from Walton. The river deposits of the great valley of the Thames have furnished its remains in comparative abundance. Its teeth occur at Hurley Bottom in Berkshire, along with bones of the ticho-

rhine Rhinoceros and the *Hippopotamus major*. The sheet of gravel also on which London stands has yielded several isolated teeth to various collectors. From the brick-pit at Ilford, on the north side of the Thames, one metacarpal has been obtained by Dr. Cotton, and two rami respectively by Mr. Antonio Brady and Mr. R. D. Darbishire, along with the remains of *Elephas antiquus*, Red-deer, and Beaver. In the corresponding sheet of brick-earth on the opposite side of the river, extending from Erith to Crayford, a lower jaw and an *os innominatum* were found by Mr. Swayne; a canine, two lower jaws, a humerus, metacarpal and metatarsal, and a phalange by Dr. Spurrell; a gigantic canine by Professor Morris. In the same county the brick-earth of Otterham has furnished two teeth, discovered by Mr. Hughes, and a similar deposit near Hartlip, in the same neighbourhood, a femur discovered by Mr. Bland. A very careful search throughout South Kent and the whole of Sussex has not revealed a trace of the former existence of the Lion in the dense Wealden forest, that, from the nature of the ground, must have over-shadowed those districts during the Post-glacial epoch. In going westward, we meet with the animal again in the low-level deposits at Fisherton, in a lower jaw found by Dr. Blackmore, and now in the Salisbury Museum. The low-level gravels also of Loxbrook, close to Bath, have yielded a remarkably fine humerus to the energy of the Rev. H. H. Winwood. A canine and humerus were also discovered by Mr. Stutchbury in the cave on Durdham Down, near Bristol.

The district, however, that has furnished the most enormous quantity of the bones of the Cave Lion, and that is entitled, therefore, to rank as its metropolis in Britain, is the western half of the Mendip range of hills. Throughout the area extending from the ancient city of Wells westward to the watering-place of Weston-super-Mare, the mountain limestone is traversed by numerous caves, of which Wookey, Bleadon, Sandford Hill, Hutton, and Banwell, are the most important. From the first four of these, between six and seven hundred specimens of the bones and teeth of the animal have been preserved in the Taunton Museum, besides at least one hundred more that have found their way into other collections. The accumulation of so enormous a quantity of remains in so small an area may be accounted for by the peculiar position of the Mendip hills, that command fertile valleys on the north, and look out towards the south and west over a plain which in Post-glacial times occupied a large portion of the Bristol Channel. Around them were the feeding-grounds of incalculable numbers of the Reindeer, Bison, Horse, and tichorhine Rhinoceros, and therefore we might expect to find the carnivora present in great force. There is evidence, indeed, that a larger number of Lions, Bears, and Hyænas dwelt

in the neighbourhood than have been proved to have lived in a similar area at any time in the past history of the earth.

To the south of this district no leonine remains have been discovered as far as the outcrop of the Devonian limestones on the shores of Torquay and Plymouth. In the Brixham cave two phalanges were found along with flint-flakes and the remains of Hyæna, Bear, and other animals; in that of Kent's Hole an upper jaw, teeth, and bones; and in that of Oreston, explored by Mr. Whidby, three canines, one humerus, one metacarpal, and two metatarsals.

Nor were they less rare on the opposite side of the Bristol Channel in South Wales. The researches of Colonel Wood and Dr. Falconer have resulted only in the discovery of an upper jaw and five teeth in the cave of Ravenscliff, three canines and a fragment of skull in that of Northhill Tor, and a fragmentary remain from those of Spritsail Tor and Longhole. From a cave on Caldy Island, teeth have been obtained by the Rev. F. Smith of Gumfreiston. A cave at Kefn in Denbighshire is quoted by Dr. Falconer as containing the remains of *Felis spelæa*, and affords the only trace of the animal in North Wales.

These are all the cases of the occurrence of the animal in Great Britain revealed by a careful search in every collection of note in the kingdom. Its absence, therefore, from certain districts cannot be accounted for on the supposition that the fossil remains have not been examined, and consequently its range through Britain, so far as extant evidence goes, is fairly represented. Its metropolis was West Somerset, whence it ranged throughout England as far as the North Riding of Yorkshire, being very rare in proportion to the other animals living at the time. Its absence from Scotland, Cumberland, and Westmoreland, and its extreme rarity in North Wales, may be accounted for by the fact, that the mountains in those districts were crowned by glaciers during the Post-glacial epoch, which would necessarily involve a climate unfitted for the great development of the Herbivora in regions much broken up into hill and valley, and the consequent absence of the Carnivores. Its absence from Ireland also may be attributed to the same cause.

We have now to discuss the paleontological value of the remains of the animal in marking the age of the deposits in which they are found. We have seen that the animal occurs more or less abundantly in bone caves and river deposits that are beyond all doubt of Post-glacial age, that is to say, which contain the remains of the Reindeer, Musk-sheep, and Mammoth. Can it boast a higher antiquity in Britain? So far as the extant evidence goes, it certainly cannot. It is found neither in the forest bed nor in the ancient land-surface underlying the

marine crag of Norfolk and Suffolk, whence the waterworn remains of terrestrial crag mammals were ultimately derived. It first occurs at Clacton, Ilford, and Crayford, and subsequently lived in incredible numbers in Somersetshire, during the full occupation of the country by the post-glacial fauna. In Kent's Hole it was associated with the pliocene Machairodus, but the occurrence of that animal does not stamp the Pliocene age of the cave because of the enormous number of Reindeer, Hyænas, Mammoth, tichorhine Rhinoceroses, and other post-glacial mammals that were also found. Its presence can only be accounted for on the supposition that it strayed up northwards from its southern habitat, very much in the same way as its congener the Tiger does now in Northern Asia. It proves, however, one important fact, that while the post-glacial fauna were in full possession of the British area, the pliocene fauna of which it is a member occupied a zoological province farther to the south.

Nor on the mainland of Europe has the Cave Lion been proved to have existed during the Pliocene epoch. In France it has been found in the caverns of Echenoz and Fovent (Haute-Saône), of Gondenaus (Doubs); of Lunelviel (Hérault); of Pondres and St.-Julien-d'Écosse (Garde); and in that of Aurignac described by M. Lartet. It has also been discovered in the caves of Bruniquel and Eyzies, and in the rock-shelter of the Madelaine, under circumstances that prove that it inhabited France at the same time that the stone-using primeval hunters lived in the country, and engraved the objects of their chase on fragments of Reindeer antler and tusks of Mammoth. In the extreme south it is quoted by Baron Cuvier from the bone breccia of Nice. It occurs also in the river deposits of Tour de Boulade (Puy de Dôme); of Abbeville (Somme); of Paris (Seine); of Soute by Pons (Charente Inférieure); and other localities. Throughout Belgium and Germany the animal occurs more or less abundantly, and especially in the caves such as those of Liége, Goffontaine, Gailenreuth, Schartzfeldt, Altenstein, and Sundwig. The first case on record of its discovery is that by Dr. John Haine, in the bone caves of Hungary, which is also very valuable, as it is the most southern point in Central Europe in which its bones have been found.

Up to the present time the animal has not been found in Spain, most probably because so few bone caves have been explored in that country. In Italy it is proved by the discoveries of M. Cesselli to have been living in the neighbourhood of Rome while the volcanoes of that district were in full activity. In Sicily the labours of Dr. Falconer in the Grotto of Maccagnone have resulted in the proof that it inhabited the island with Man, the Hyæna, Hippopotamus, and *Elephas antiquus*.

Thus there is proof that the animal ranged throughout France and Germany, as far south as the basin of the Upper Danube, and throughout Italy as far as the extreme point of Sicily. It has not, up to the present time, been discovered in Scandinavia, Denmark, or Russia. There is no reason to believe that any of the deposits in which it occurs throughout this great area are of other than Post-glacial or Quaternary date. Nevertheless it would be rash, in the present state of our knowledge of the pliocene Felidæ of those countries, to affirm that the Cave Lion was not an inhabitant of Europe during the Pliocene epoch.

There is also unexpected proof that the Cave Lion inhabited North America, during the Post-glacial or Quaternary epoch. In 1852 * Dr. Leidy figured and described a left lower jaw from the neighbourhood of Natchez, Mississippi, which he considered to possess leonine affinities, and yet to differ from any recent or extinct feline species. The two most characteristic points which it presents are the great depth of the ramus and the forward position of the ramal process underneath premolar four. In all other respects it coincided remarkably with the jaw of the Cave Lion. The minor differences brought forward by Professor Leidy vanish away at the comparison of the large series of leonine jaws in the Taunton Museum. Mr. Sandford, however, recently discovered an abnormal jaw of the Cave Lion in Mr. Beard's collection from Bleadon Cave in Somersetshire, that presents exactly the same characters by which the American jaw differed from the normal jaw of the Cave Lion, the ramal process occupying precisely the same forward position, and the depth of its ramus measuring 2·77 inches beneath premolar four, as compared with the corresponding measurement of 2·5 in Dr. Leidy's figure. In the latter, moreover, the thickness of the covering of peroxide of iron is not taken into account. We are therefore compelled to admit that specific difference has not yet been proved to exist between the American (*F. atrox*, Leidy) and the Cave Lion, and to believe that the jaw in question really belongs to the latter animal. Contrary to what might have been expected, it differs more from that of the great South American Felis, the Jaguar, in the enormous development of the ramal process, than does that of the existing Lion of the Old World. The associated remains found at Natchez belong to Bear, Bison, Horse, and Mastodon, as well as to extinct representatives of the South American fauna of the time, Megalonyx and Mylodon.

There is nothing *à priori* unreasonable in the idea that a

* "Trans. Amer. Philosoph. Soc. Philadelphia," vol. x. N.S., pp. 319, 321, Pl. 34.

geographical variety of the Cave Lion should have lived in North America during the Post-glacial or Quaternary epoch in that area, when we recollect that the Mammoth, Bison, and Horse, of the Europæo-Asiatic post-glacial series have a similar range. There is no doubt of the specific identity of the American with the European Mammoth. *Bison Americanus* has been found in the fossil state at Bigbone Lick, Kentucky. The Bison associated with the American Lion at Natchez is considered by Dr. Leidy to belong to a new species, *Bison latifrons*; but since there is no point of difference between it and the enormous Bisons of post-glacial Europe, we cannot agree with him in the belief that Baron Cuvier was wrong in ascribing the remains to the Aurochs. *Equus Americanus* does not present any specific difference when it is compared with the many forms of the European *Equus fossilis*.

So far, then, as we have any evidence of the American Lion, it is a link in the chain that binds the post-glacial fauna of North America to that of Europe and Northern Asia; and we may fairly argue that it bore the same relation to that of the European caves as the American to the European Bison, the Bear of the barren grounds to that of Europe, or the Canadian Elk to that of the Old World. Its occurrence in America is not more startling than that of the Musk-sheep in the south of France. It extends, however, the range of the Lion eastwards, through Russia and the vast steppes of Northern Asia, across Behring's Straits into the treeless barren grounds of North America, and thence southwards into the zone of the woods, and over the feeding-grounds of the Bison down to the almost tropical region of the Gulf of Mexico. Subsequent investigation will probably prove its former existence in the intermediate area, as in the case of the Mammoth. What we know of the living Carnivores, such as the Wolf, Fox, and Tiger, would naturally lead us to expect those found in a fossil condition to have a wider range than any of the Herbivora.

We have already shown that the Lion ranged through North-western and Southern Europe, and that it occurs also in the New World. In conclusion, we will only add that it was lingering in the plains of Thessaly and hills of Macedon when the father of history wrote his account of the invasion of Greece by Xerxes. The last historical notice of its sojourn in Europe is that afforded by Aristotle. It became extinct in Europe some time between 330 B.C. and the days of Dio Chrysostom Rhetor (A.D. 100). The cause of its disappearance from Europe is to be attributed to the attacks of the hunter and to the encroachment of cultivation on its ancient haunts.

PASSION FLOWERS.

By MAXWELL T. MASTERS, M.D., F.L.S.

[PLATE XLIV.]

THERE are some plants which arrest at once the attention, not only of the curious, but even of the casual observer. Passion flowers afford a good illustration of this statement. Their elegant climbing habit, their slender tendrils, their striking foliage, their flowers, as singular in their structure as they are beautiful in their appearance, to say nothing of the legends attaching to them, amply account for the interest felt in these plants, alike by the scientific botanist and the dilettante. This interest has been heightened of late by the singular facts that have been brought to light by those who have been making experiments on the subject of cross-fertilization or hybridization. Time was when the botanists, with some few exceptions, looked rather contemptuously than otherwise on cross-breeds and such-like mongrels, and deemed them unworthy the attention of *la haute science*. And, even now-a-days, there are some surveyors who look askance at "garden hybrids," however beautiful, because the said hybrids do most undoubtedly destroy and obliterate, to a very great extent, the landmarks erected, at no little cost of time and labour, by the surveyors aforesaid. Nevertheless, in a gardener's point of view, the result is in general so satisfactory, that what he calls an improved "strain" is produced, while, physiologically, the gain is so great as to compensate, in no little degree, for the technical confusion that arises from the operations of the hybridizer.

The general reader will find in Mr. Darwin's "Variation of Animals and Plants," vol. ii. p. 137, a general summary of the results obtained by experimenters in this beautiful genus, so that it is unnecessary to go into details here. The most striking fact elicited is, that many of the so-called species refuse, either entirely or partially, to be fertilized with pollen of their own kind, while, almost without exception, they set freely, not only when pollen from another individual of the same species is applied to their stigmas, but quite as freely, or even more so,

when the pollen of some other species is employed. This is another proof, either that the old doctrine, as to species not intercrossing, is not wholly true, or else that we must greatly extend the limits of what we are pleased to call species. The conformation of the flowers throws some light on these peculiarities, hence it may be advisable in a very general way to refer to their structure.

Beginning with the bracts below the flower, we have only to remark that their number is invariably three, and though their form varies much in the different species, and often indeed affords good means of distinguishing them one from another, they do not apparently affect the proceedings within the flower itself. Within the bracts is the flower proper, consisting of a top-shaped or urn-shaped tube, surmounted by the calyx-lobes and (when present) by the petals. Inside these comes a series of fringe-like threads in one or more rows, the outermost usually distinct from each other, the inner ones often so closely united as to form a little sheath or membranous ring, with only the tips of the component threads detached. These threads are collectively called the "corona," or the crown, and they serve to separate the upper part of the calyx from the lower part, which has been rightly called the nectary, inasmuch as there, and there only, is the honey-like liquid secreted. This nectary is really the interior of the urn or top-shaped tube of the calyx, to which we have before alluded; its form varies greatly according to the species, but its function, so far as we have seen, is the same in all the species. We shall presently see the use of all this apparatus which adds so greatly to the beauty of the flowers, and pass on now to the other organs of the flower. Standing up in the centre of the nectary and protruding beyond it, is the column sometimes called the gynophore, or the gynandrophore, because it bears the male and female organs This column is girt, near the base, by a broad pulley-shaped ring, which, with the inner row of the corona, serves to shut off the nectary proper from the other floral organs. From near the top of this column the five stamens proceed, each bearing an anther, which originally has its inner face pressed up against the ovary in the centre of the flower, but which, before the pollen is ripe, alters its position so as to turn its face towards the outer side of the flower. The purport of this change we shall explain by and by. As for the pollen in the anthers, let every one in possession of a microscope, and who has not already done so, take the first opportunity of examining it. Richly will he be rewarded, for there are few things more beautifully marked than these little pollen globes of the Passion flower. Above the stamens, perched at the top of the column, is the ovary, surmounted in its turn by three styles, which with their thickened

[illegible] M[illegible] W. West, imp

Passion Flower

stigmas are well called club-shaped. The interior of the ovary consists of a single cavity, to the sides of which the young seeds or ovules are attached in three linear groups. In due course, if properly fertilized, the ovary ripens into a berry-like fruit, and the ovules become seeds.

We have been thus minute in describing the general construction of the flower, because it is impossible to comprehend either its true nature or the way in which the flowers become fertilized without entering into these matters. The discrimination of the very numerous species of the genus depends on minor variations in these details; moreover, one object in penning these notes is to show how much interest may be derived from the investigation of any single flower, if only the observer will be content to dip beneath the surface, and not, after having filled his eyes with a sense of beauty, rush off to fresh fields and pastures new, without even an attempt to pick up the jewels of which he sees only those that are perforce brought under his very nose. Well! wherein does the interest lie? some one may enquire who sympathizes with Peter Bell, and considers a Passion flower to have been constructed for no other end than to adorn its native woods, or to add another charm to the conservatory. The interest lies in many directions; but it must be sought for; it will not come without a little painstaking, but the reward far outweighs the pains required to search. The search must be prosecuted in the same way as, but with a little more care and judgment than are exercised by a child who pulls a toy to pieces to see what it is made of; with the same feelings that induce a mechanist to examine a piece of machinery, to ascertain its construction, and to see how it works. If a little romance, or some historical associations, can be interwoven with the more practical facts, all the better, always provided that Minerva and the Muses know their proper places, and, while each helps the other, takes care at the same time not to get in her sisters' way.

The main features in the plan of construction being as above described, it is worth while, before seeing what the several parts are told off to do and how they do it, to enquire a little further as to what they are: what, for instance, is the top-shaped or urn-shaped body at the base of the flower, and which, as before said, secretes the honey in its interior? Botanists call it the calyx-tube. They say that the calyx is made up of five segments, joined into a tube at the base; but is this so? We think not, and for these reasons. Everyone knows that leaves are produced from branches or from stems as a general rule, and that it is a circumstance of the rarest occurrence for a leaf to sprout from another leaf. Such a thing does happen in Begonias now and then, in cabbages more frequently; but when-

ever it does occur, it is looked on quite as an exceptional circumstance.

Now the calyx is universally admitted to consist of (modified) leaves; but if this urn-shaped mass, whose nature we are considering, consists of leaves, as the term calyx-tube implies, we have, as a constant occurrence, the production of other leaves in great numbers, and with great regularity from it. Cut the flower through its centre from below upwards, and it will be seen that from the top and inner surface of this urn spring the petals and all that series of threads and rings which makes up the "crown." Is it likely from what we know of the manners and customs of leaves, that they would give off all these varied outgrowths? It is quite possible that they might do so, but that is not the question. Is it probable? We think, having regard to general usage as above stated, that it is not. There are other reasons of too abstruse a character to be entered into fully here, which lead us to the opinion, that this urn is no calyx-tube properly so called, but that it consists of the top of the flower-stalk, the thalamus, or receptacle, as it is technically called, which grows in this peculiar urn-like form, and gives off from its top and its sides, as a properly conducted thalamus always does, the several organs of the flower of which mention has been made. Though it would be out of place to give the details which have led to this conclusion, we may say that they are based on a consideration of the way in which the urn grows from babydom to maturity, which is after the fashion in which branches grow generally, (the thalamus or receptacle is only the end of a branch,) and from an examination of the microscopical structure, which is more akin to that of a branch than that of a leaf. Still, if in these notes we occasionally call the urn a calyx-tube, we must plead excuse that it is so called in all descriptive books, and that expediency often urges the retention of a particular name when absolute correctness would banish it. As the question is to some extent one of words only, and the above confession and explanation have been made, it is to be hoped that if, for the sake of conformity with old customs, the word calyx-tube is here sometimes used, the writer will not be set down as more inconsistent than his fellows in general, with whom it is certainly not an unusual thing to say one thing and mean another, and this in no evil sense.

Then a question arises as to the nature of that extraordinary, and often beautiful, apparatus of threads and knobs and fringes which collectively form the "corona." They occupy an intermediate position between the petals and the stamens; and hence, while some have considered them to pertain to the one series, others have allotted them to the other; while a third set of speculators have run with the hare and hunted with the hounds,

by pronouncing them to be as intermediate in their nature as they are in their position between the stamens and the petals. We are not sure, after all, that they are not right, as the organs in question seem to be neither fish, flesh, fowl, nor good red-herring. What we know for certain about them is this, that they are not formed till long after the other parts of the flower are developed; and this fact, with some people, is taken as evidence that the organs in question are of little importance. They look upon such "appendages" as of no account, by reason of their late appearance; but we believe this want of appreciation arises mainly from ignorance of the functions these certainly very ornamental appendages are called on to perform.

Their very structure should lead us to infer that they are of more importance than these gainsayers would admit; for each tiny thread has its own separate cord of spiral vessels permeating it, and we know pretty well that these vessels do not show themselves where they are not wanted; and, on the other hand, they do manifest their presence wherever there is something going on. What office does the corona serve? To this intensely practical question we return answer, that it materially aids in the process of fertilization. We say this in a general way, without pledging ourselves to the accuracy of all the details. But our opinion is formed from a consideration of these facts:—1. That the nectary, or true honey-secreting surface, is below the corona. This is obvious anatomically and gustatorially. 2. That the anthers, when ripe, open in a direction downwards and outwards, away from the stigmas of their own flowers, and are above the corona (supposing the flower to be erect or nearly so). 3. That, when in this position, it frequently happens that pollen falls on the corona. 4. That there is reason to suppose that the perfume of the flower resides in the corona, as, when this is cut away, the flower becomes scentless; at least so said the late Professor Morren.

With these facts in his remembrance, let the observer watch a humble bee as he alights on a fully expanded Passion flower. Attracted, perhaps, by the perfume or the colour, one or both, the insect makes straight for the nectary and its honeyed treasures; but to get at them he has to wriggle about amongst the rays of the corona, so as to get his proboscis down to the base of the flower. All this while his hairy back is just under the anthers, and it would be odd indeed if some of the pollen did not attach itself to his hair-shirt, and thus get conveyed to the stigma of some other flower. But, to make our case complete, it is also necessary to watch the movements of the styles. In the young state they are erect; then they spread horizontally, or even become reflexed; lastly, fertilization effected, or even if such process has not taken place, they again assume a vertical

direction as the flower withers. Similar movements take place in the stamens, and, from the facts just mentioned, it is pretty clear what is the meaning of all these bowings and curtseyings. If the stigmas be in the horizontal or deflexed position when the bee with pollen-dusted back is groping about among the threads of the corona, it is clear that the insect is, very unwittingly perhaps, not only securing his own dinner, but adopting the best means of ensuring a similar repast for future generations of insects; at any rate, he is doing his best to secure the formation of fruits and seeds.

The fruits, in some cases, as in the case of the granadillas of the West Indies, are highly prized for the refreshing, perfumed juice which surrounds the seed. There is one drawback to their use in the West Indies. The plants make delicious shady arbours, says Jacquin; their flowers are beautiful and fragrant, their fruit cooling and richly flavoured; but these qualities offer attractions to other beings besides human creatures. Squirrels are partial to the fruit, and snakes are partial to the squirrels, while men, however tolerant of squirrels, are not fond of snakes as a rule.

The granadilla, as usually seen, bears a fruit of the size and form of a swan's egg, and of a rich olive-yellow colour externally. It is not unfrequently ripened in hothouses in this country. The pulp is highly perfumed, and the flavour is recherché; but perhaps the best way to eat them is to make them into a conserve—*experto crede*. The granadilla is not the only edible variety; there are several others, such as *P. laurifolia*, *P. edulis*, a purple-fruited variety, by some preferred to the granadilla, and the "tumbo" of Peru, *P. macrocarpa*, very like the granadilla, but having a fruit as big as a quartern loaf.

Now for the legend concerning these flowers, on which indeed their very name depends, and which runs thus:—When the Spanish Jesuits visited South America, after the conquest of the tropical portions of that continent, in their zeal for the propagation of the faith and for the enlightenment of the untutored Indian, they appealed to the Passion flowers, with whose beauty they were struck, as signs and symbols of the passion of our Lord.

The outstretched hands of the scoffers were supposed to be represented by the palmate leaves which some of the Passion flowers bear. The tendrils symbolized the scourge. The sepals and petals typified the apostles, two of whom—Peter, who denied, and Judas, who betrayed the Saviour—were absent; and hence there are only ten segments to this part of the flower —five sepals and five petals. The corona corresponded to the halo or nimbus of glory; or, as some say, to the crown of thorns. The five wounds were pourtrayed in the five anthers, and the

three nails—two for the hands and one for the feet—were indicated by the three stigmas.

Certainly these similitudes are ingenious, and not more far-fetched than some others which pass current even now.

It is not necessary to say more in support of the assertion that, on many and very varied grounds, Passion flowers are worthy of the admiration and study of all plant-lovers.

EXPLANATION OF FIGURES.

Plate XLIV.

Fig. 1. Portion of a branch of a species of Passion-flower, showing one fully-expanded and one withered flower. In the former the sepals and petals and one row of the "corona" are reflexed. A second row of the corona is erect, and above it is the "column," bearing the stamens and pistil. (From a sketch by Miss Ormerod.)

„ 2. A section through a flower of another species of Passion-flower (*P. cincinnata*). On either side of the lower part of the flower are the bracts, on one of which are shown two rounded glands; above the bracts are the sepals (shaded) and petals. Within the petals some of the threads of the corona are shown; the outer ones long and wavy, the inner ones are shorter and converge around the column. In the centre is the column bearing the stamens. The anthers are turned downwards, so that their faces look towards the corona. Above the stamens is the ovary, surmounted by the three club-shaped styles.

THE NATURAL DEVELOPMENT OF BACTERIA IN THE PROTOPLASMIC PARTS OF VARIOUS PLANTS.

By M. A. BECHAMP.*

THE pulp of portions of soft and green plants is speedily invaded by myriads of bacteria, of varying size, and doubtless of different species. Before this invasion, the microscope shows nothing in the pulp but cells and molecular granulations. It is alleged that the air conveys into the artificial medium created by the friction of the vegetable parts, either the germs of bacteria or the bacteria themselves; it is also alleged that these bacteria are the result of spontaneous generation. This note is intended to show the small foundation existing for either of these views. The fact is, that, despite all precautions, if we do not kill the molecular granulations (by means of heat, or by the use of creosote or phenic acid in a coagulating dose), we cannot prevent the appearance of bacteria. This is because the plant really and naturally contains in itself the germs of these bacteria; to wit, the microzymas or molecular granulations.

After the frosts we had at Montpellier during the winter of 1867–68, I had occasion to observe two frozen plants of *Echinocactus*. Some weeks after the thaw, I investigated the kind of histologic change which the freezing had caused in the tissue of this plant. The epidermis bore no trace of lesion, and was as resilient as before the frost; evidently the great density of the tissue and its thickness proved a sufficient barrier against the penetration of bacteria, vibriones, or their germs. On an incision being made into the protoplasmic portion, the matter taken from the deep part of the wound, or immediately under the epidermic layer, contained myriads of bacteria, in which the *Bacterium termo* and *putridinis* were predominant. At the time when I was drawing up these observations, for the purpose of publishing them, I, with M. Estor, was occupying myself with the microzymas of animal organisms, and, in the interval, M. Davaine published his "Physiological and Patho-

* Translated from the French by C. H.

logical Researches on Bacteria." My observations appeared to me to give a different explanation of the results obtained by M. Davaine; I therefore wished to verify and establish my opinion by examining other instances of frozen plants. During the frosts which occurred at Montpellier from the 25th to the 30th of January last, I obtained a number of frozen plants, and examined them from ten to twelve days after the thaw.

The observations conducted by me were made on the following plants:—*Opuntia vulgaris*, *Calla Æthiopica*, *Agave Americana*, *Datura suaveolens*, *Solanum aviculare*, *Entellea arborescens*, *Cyperus papyrus*, *Nerium oleander*, *Melanthus major*, *Echinocactus rucarinus*. They lead me to the following conclusions:—

1. Notwithstanding that the contrary is believed, bacteria can become developed in an acid medium, which can remain acid or become alkaline, as well as in a medium absolutely neutral or remaining neutral. On some future occasion I shall adduce new proofs in support of this proposition.

2. The normal microzymas of plants, like those of animals, may evolve bacteria; and since in a single plant many forms, if not many species, of these bacteria may appear, I think we should in this perceive the demonstration that many sorts of microzymæ may exist in one plant.

3. In those experiments in which the plants are inoculated with bacteria, it is probable that these bacteria do not multiply; they only provoke a change of medium, which becomes favourable to the evolution of the normal microzymas of the animal into bacteria, and to the disturbances which thence result.

4. In the studies made on the spontaneous generation of low organisms, or of a simple cell, note has not been taken of the molecular granulations. I have shown these hitherto to be active everywhere—in chalk, in fermentations, in plants, and in animals.

5. Finally, these new observations confirm and extend, on one hand, the researches published by M. Estor and myself; and, on the other, those published by M. Mouchy, from experiments made in my laboratory.

In a forthcoming work, I will report the experiments relative to the chemical function of the bacteria developed in frozen plants.—*Comptes Rendus*, February 22, 1869.

REVIEWS.

MOLECULAR AND MICROSCOPIC SCIENCE.*

THE present work was not wanted to demonstrate Mrs. Somerville's great reading, keen powers of observation, or thoughtful and comprehensive mind. And when we ask ourselves whether it increases our former opinion of the most eminent scientific woman in Great Britain, we are bound to answer honestly that it does not. From beginning to end, this, the last work which the author has given to the world, is a mistake. It is wrong in its conception, and imperfect in execution. It shows that its author is widely read, and is as industrious a worker as ever. But, on the other hand, it presents her to us as a compiler of an inferior order, who attempts a task all but impossible to carry out with any satisfactory degree of completeness. In these two handsome volumes, Mrs. Somerville has tried to unite the history of animate and inanimate nature in their molecular aspects. She has sought to show—at least so we judge of her labours—that matter, whether it be organic or inorganic, manifests all its phenomena through modification in the relation to each other of a number of infinitely minute particles. But to do this adequately, in so far as the idea is applicable to even a few of the manifestations of the physical universe, would take a far greater number of volumes than the author has devoted to the whole subject. It is for this reason that we are compelled to believe that Mrs. Somerville has rather diminished than enhanced her scientific reputation in producing the work under notice.

The operations of physical force as they manifest themselves in inorganic substances occupy the first part of the first volume; and, as a history of the wonders of modern physics, this part of the work is of much interest, though in portions it is perplexingly discursive. The headings of the sections which this part embraces are as follows:—I. Elementary constitution of matter. II. On force, and the relations between force and matter. III. Atomic theory, analysis, and synthesis of matter, utility of waste substances, coal-tar colours, &c. IV. The solar spectrum, spectrum analysis, spectra of gases and volatilised matter, inversion of coloured lines, constitution of sun and stars. These are the titles of the sections as given in the contents-table, but they give no idea of the number of questions discussed in the text. Indeed, this first part of the first volume is a "tightly

* "On Molecular and Microscopic Science." By Mary Somerville, in 2 vols., with illustrations. London: John Murray, 1869.

packed" condensation of recent work in chemistry and physics. It contains such an amount of matter that it becomes quite a labour to read it, for we might as well take up a dictionary, so "cut and dry" are the facts, so crude, so undigested, so slightly connected are the statements. There is little in the shape of generalisation, and almost less in the form of general reflection. All through it is Mr. So-and-So did this; Professor —— did that; so many millions of miles, or pounds, or suchlike. This part of the book is a very tangled forest of the discoveries of physicists, through which one has to cut one's way with force, and of which, when travelled through, one knows very little that is either useful or improving. By far the most interesting section is that devoted to the results of spectrum analysis, which may be looked upon as a very full and fair exposition of our knowledge up to the beginning of last year.

The minute structure of the substance of plants occupies the second part of the first volume, and offers nothing new either in fact or mode of treatment. Everything that it contains is to be found more correctly stated and similarly illustrated in the works of the Rev. J. M. Berkeley, Dr. Carpenter, and indeed in most good treatises on Physiological Botany. We should perhaps make an exception in favour of the brief account which is offered of Mr. Darwin's discovery of the floral peculiarities of orchids.

The second volume is confined to descriptions of the animal world, but even here we fail to see that the author has given any justification for the types she has selected. Assuredly, she has not limited her remarks to microscopic creatures, nor has she, when writing of other and larger animals, dealt exclusively with their histology. Indeed, altogether, this is the worst part of the book, and has only one redeeming feature—the illustrations. The latter have been selected from sources not familiar to the general public, and the artist has drawn the figures in white on a dark indigo background, which gives them great beauty, attractiveness, and effect. We refer especially to the page-plates, which represent some beautiful examples of the oceanic Hydrozoa, the Polycystina, and the other forms of Rhizopoda. The descriptions of structure are accurate, but they are most unequal in merit, and sometimes whole groups—like the Infusoria and the Rotifera, perhaps the most interesting microscopic forms in the whole animal kingdom—are disposed of with a degree of conciseness more decided than desirable.

There are two well-marked defects in this work of Mrs. Somerville's to which we must call attention ere we close this brief notice: these are the multitude of typographical errata, and the tendency which exhibits itself in every page to father on a writer a doctrine or theory which he merely in common with others has employed. This last is a vulgar offence, and one which those who make books for the public should avoid. Thus we are told in one place that "Dr. Carpenter has shown that it is by a series of forces acting on matter that man conveys his ideas to man,"—just as if Dr. Carpenter ever did anything more than hand this doctrine down from those from whom he himself received it. As we have said, we fear too often, we are most dissatisfied with this work, and the following paragraph, which we quote from the first section in the second volume, would be in itself alone enough to condemn the whole work, as one devoid of the philosophic feeling

which the subject demands: "To suppose that the vital spark is evanescent while there is every reason to believe that the atoms of matter are imperishable, is admitting the superiority of matter over mind; an assumption altogether at variance with the result of geological sequence; for Sir Charles Lyell observes that sensation, instinct and sensation of the higher mammalia bordering on reason, and, lastly, the improvable reason of man himself, presents us with a picture of the ever-increasing dominion of mind over matter." *

We certainly never gave Mrs. Somerville credit for the feminine mode of reasoning; but anything more supremely ridiculous, more incongruously put together, and indeed more nonsensical, than the foregoing passage, we have never seen, even in the worst type of female philosophy.

VESUVIUS.*

VESUVIUS has attracted much attention during the past few years from both British and Continental geologists, and, as a natural consequence, much good work has been done in this branch of science. All have been engaged in studying the phenomena of the recent outbursts; but some have pursued their enquiries with the help of the spectroscope, some have approached the research from a chemical stand-point, others have gone into the question of how far physical indications, such as variations of the magnetic needle and delicate vibrations appreciable only by the seismometer, are associated with the discharge of lava from volcanoes. But all may be said to have one great problem before them—to find out the source of the heat by which masses of rock become liquid, and are raised to such considerable heights. Further, there presents itself for solution the complex question as to the early condition of our globe, a question which can only be answered when the phenomena of mountains like Vesuvius are fully explained. Professor Phillips therefore determined to write as it were the clinical history of Vesuvius, to describe the different phases of its eruptive affection, and, if possible, to show how the results of recent investigations have helped us toward a rational diagnosis. In the handsome volume which Messrs. Macmillan have issued, the Oxford Professor has certainly done a good deal towards producing a monograph on Vesuvius; but we shall be expressing our critical opinions very mildly indeed when we say that his appearance in the field need not deter others from giving us the fruit of their exertions in the same area of labour. In other words, we may say that Professor Phillips has not exhausted his subject, and has not given us all the information we had hoped for from a geologist of his very broad experience and his very great erudition. About half the volume embraces the history of Vesuvius prepared from various records, and leading us up from the time of Pliny through the seventeenth and eighteenth to the nineteenth century. This part of the work will carry away the interest of the general

* "Vesuvius." By John Phillips, M.A., F.R.S., Professor of Geology in the University of Oxford. Oxford: Clarendon Press, 1869.

reader. It is most graphically and forcibly written, and the illustrations—chiefly from sketches of the author's—possess an artistic character which is not often found in treatises of this class. The illustrations of some of the old streets in the buried city of Pompeii are unusually clever pen and ink drawings. The second part of the work describes Vesuvius as it is, and deals with the more recent volcanic eruptions. This portion of Professor Phillips's writings includes a discussion of the various questions of physical geology related to the manifestations of volcanic agency. Here we find an account of the characteristic phenomena of eruptions, the relations of periods of rest to periods of activity, the form and structure of Vesuvius, the Phlegræan fields, the minerals of Vesuvius, volcanic energy, and Vesuvian lava. The last chapter in the book is really the only one which is of special interest to the physical philosopher. It is entitled "General views leading to a theory of volcanic excitement," and contains the latest opinions of Professor Phillips on this the all-important Geological question of the day. Our readers will be aware that speculation at the present moment turns upon the axiom that the earth was formerly an incandescent mass.* It is satisfactory to find, then, that so excellent a thinker as Professor Phillips "inclines his thought" in this direction. Indeed, he as much as admits that the earth has cooled down to solidity from a former fluid condition, as will be evident from the following concluding paragraph of his last chapter:—

"Here, then, we pause, not without a conviction that Geology is acquiring, even with reference to the variable might of subterranean fire, a sure ground of conviction that it is a part of the system of slow and measured change, which has been traced in operation through the members of the solar system and the starry spaces beyond, to the greater and more distant masses of shining vapour, which, though they stand to us at present as the 'Flammantia mœnia mundi,' may even now be silently gathering into new suns and planets and satellites, or forming elliptic rings of asteroids, such as were seen on the morning of November 14, 1868, by the author at Oxford."

We have to congratulate Geologists on the fact that so eminent a member of their body adheres to the nebular hypothesis, for such it virtually is. At the same time we cannot declare ourselves thoroughly content with this work of Professor Phillips's. From its pages we learn nothing of what has been done either with the compass or the spectroscope. Fouqué and Palmieri receive very scant justice at the author's hand, and the important labours of Forbes and Sorby are slurred over in a manner which is as discreditable to Professor Phillips as it is unjust to the chronicles of British progress in Philosophical Geology.

* The Reviewer was not aware that Mr. Forbes discusses this extremely interesting subject in his article in the present number.—Ed. *Popular Science Review.*

SPONTANEOUS GENERATION.*

THOSE who read the admirable exposition of the doctrine of Heterogeny which Dr. Hughes Bennett gave in his article on the molecular origin of Infusoria (*Popular Science Review*, January), will be prepared to comprehend the essay of M. Pennetier, which has now reached its third edition, and which is so excellent a work that we trust it may soon find an English translator. M. Pennetier is not merely an advocate, he is also a witness, and his evidence, laid in various memoirs before the Academy of Rouen, has contributed largely to swell the formidable mass of testimony which the followers of M. Pasteur have in vain tried to overthrow. Indeed, M. Pennetier's position as a champion of the doctrine of spontaneous generation is so little inferior to that of M. Pouchet himself, that the latter says of the work under notice that it "is a remarkable summary of all that has been done up to the present time in Heterogeny, and will remain a model of strength operating under the influence of reason and good faith." This little volume extends over about 300 pages, is abundantly illustrated by well-selected woodcuts; and must be regarded as a complete account, historical, descriptive, and ratiocinative, of the important doctrine it treats upon. It is divided into about fourteen chapters, and contains a valuable and tolerably exhaustive bibliography in the form of an appendix. It is out of power, owing to our limited space, to give an abstract of each chapter; and indeed it is unnecessary, as those who are interested in the subject must read the work for themselves, and a brief sketch of some of the more striking parts of the work will give a sufficient notion of the general character of M. Pennetier's arguments. The question now at issue between those who assert the fact of spontaneous generation and those who deny it is considered by many to be a very unintelligible and abstruse one; but it is nothing of the sort. It lies in a nut-shell, so to speak. Whence does such a substance as common mould come? How is it that a vessel of water containing decaying vegetable matter, although at first devoid of traces of animal life, soon becomes charged with living organisms animal and vegetable? Those who hold the generally accepted belief thus explain this phenomenon. The air is charged with the floating germs of infusoria, fungi, and such like, and these find a favourable nidus in decaying vegetable solutions, in which they develope into perfect beings. It is just as the seeds of corn, "some fall by the wayside" and are lost, but others reach fertile soil, or, in other words, meet favourable conditions, and therefore germinate and grow. This is, after all, in great measure an assertion, just like the gratuitous assumption that all species of animals were separately created. And just as Mr. Darwin has knocked over the latter, so M. Pouchet endeavours to overturn the former hypothesis. It is certainly a difficult task in both cases. The opponents are in each instance expected to prove a negative, and we are of opinion that in the two cases they have very nearly succeeded in doing so. Anyhow, the majority

* "L'Origine de la Vie." Par le Docteur Georges Pennetier; ouvrage illustré de nombreuses vignettes sur bois, avec une préface par le Dr. F. A. Pouchet. 3rd edition. Paris: Rothschild, 1868.

of fact lies on the side of the iconoclasts. If this be so, says the reader, then M. Pouchet must have this position:—1. He must show that there are no facts in support of the current opinion; 2. He must prove the absence of those myriads of germs; and 3. He must show that the air being so acted on as to destroy any germs it might contain, it yet allows of the formation of organisms. And this is so. There are unquestionably no facts beyond the great fact—the terribly serious fact in the struggle of doctrines—of traditional belief, in favour of the doctrine of innumerable germs—at least none that we know of. As to the other two points, we opine, from a careful study of this volume of M. Pennetier's, that they are very nearly conclusively demonstrated. To lay before our readers the evidence therein adduced would be to anticipate the author. We shall therefore merely refer to one or two passages in chapter v., in which it is shown that the atmospheric germs do not exhibit themselves to the extent that the Panspermists lead us to believe. "That air had been examined only as to its chemical and physical qualities, till MM. Moscati, Robiquet, Baudrimont, and Pouchet thought of submitting it to microscopic examination. M. Pouchet, among other contrivances, used for this purpose an instrument devised by him, and which he termed an Aeroscope. In this the air was projected against discs of glass, which thus collected the corpuscles it might contain. When the powder or dust thus collected was examined, it was found to be composed of products of food and manufactures—such, for example, as starch, grains of silica, filaments of wool and cotton, bits of clay, soot, and the *débris* of plants and insects; a very few spores and infusoria were occasionally found. If, instead of experimenting on the air of populous towns, the air was collected from mountains, or on the surface of the ocean, the nature of the collected corpuscles was found of course to vary in accordance with the locality. MM. Pouchet, Joly, and Musset, who thus examined air in every position and locality, have drawn especial attention to the rarity, and most frequently the absence of either the ova of infusoria or the spores of cryptogams. These savants conceived the ingenious idea of making a microscopic examination of snow (which of course in its fall would enclose the germs), and they found exactly the same results as those stated. M. Pouchet even went so far as to examine the dust deposited from the air enclosed in the cavities of the bones of birds, and found its composition in exact accordance with the locality inhabited by them. The fowl reared in our towns, and the wild falcon showed in this respect very remarkable differences. On their part, Burdach, Von Bär, Heusche, Ehrenberg, R. Wagner, Leuckart, and more recently Wyman, Béchi, Schaafhausen, and Baudrimont, have also equally clearly proved the normal absence of ova and spores in air. I hasten to say," adds this latter observer, "that up to this I have never met in the air we breathe those fantastic beings, those monsters with whom human imagination has peopled it."

M. Pennetier then takes up the pseudo-positive observation made by Lemaire and others, and shows that in no case in which the air was examined immediately after being collected were organisms found, and that no test was employed to show whether the so-called spores were silica or not, and it happens that the siliceous particles are remarkably like in form the spores of certain cryptogams. We have said sufficient to show the importance and interest of this volume, and we now conclude our observations by giving it a hearty commendation to our readers.

THE POLAR WORLD.*

THE researches of Professor Heer, and of Mr. Whymper and others, have lent a new interest to the polar world, and have given us a new incentive to arctic exploration. Hitherto the only object we could suggest as justifying polar expeditions, was the trivial one of the possible discovery of a useless north-west passage, or the very questionable one of the discovery of an open polar sea. But we know now, thanks to the labours of these savants, that the polar regions must at one time have enjoyed a climate as different from that they now experience as ours is from that of Northern Africa. Indeed there can now be no longer a doubt, that at one period of the earth's history, the climate of Greenland was even more than temperate, and the country possessed a luxuriance of vegetation such as could never have been dreamt of but for the discoveries of Heer and his colleagues. These discoveries relate to the fossil flora of Greenland, and they show us that at a time remote from the present, the polar regions of the globe must have had climatal conditions as different as possible from those which now prevail. Anyone, therefore, who would select this aspect of the polar world, and would give us a good work upon the prehistoric polar world, would not only do a service to science, in extending a knowledge of its truths, but would do much to encourage arctic exploration. Here is a whole field for study and investigation: will no one take it up? Ostensibly Dr. Hartwig has taken it up, but only ostensibly. His book, full of interesting details as it is, can hardly lay claim to being considered scientific, since the question of most scientific interest in connection with the subject is left, we may say, altogether unnoticed. It is true that he mentions the fact of a former temperate climate, and corresponding vegetation. But his observations on these do not extend beyond a page and a half, and they close with the most absurd blunder in reference to Oswald Heer's explanation of the cause of the alteration of climate. Indeed the concluding passage is a guarantee of Dr. Hartwig's unfitness for the task he took in hand. He makes Heer say that as the solar system is moving through space, and as the fixed stars are blazing suns, it must sometimes be placed in a thicker cluster of fixed stars than usual, hence the earth must get warmer. The warm period of the poles corresponded to a time when the solar system was thickly surrounded by stars. Since then we have passed into a less "populous sidereal region," and hence the change. This is science with a vengeance. The popular, or non-scientific parts of the book contain instructive sketches of the inhabitants of the European, American, and Asiatic Polar districts, and many pleasant anecdotes clipped from the books of arctic explorers. The illustrations are numerous and pretty, but we cannot commend the work as an accurate one.

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* "The Polar World: a popular description of Man and Nature in the Arctic and Antarctic Regions of the Globe." By Dr. C. Hartwig. London: Longmans, 1869.

ON SPECTACLES.*

IT was good that Scheffler's excellent treatise should have been translated into English, but it was better that it should have fallen into such thoroughly competent hands as those of Mr. R. B. Carter. A really reliable work on the condition under which spectacles should be selected was much required, and such a work is that now before us. It is true that the general handbooks of ophthalmic surgery contain directions for the choice of spectacles, but in nearly all cases these are of an empirical kind, devoid of exactness, and dealing with a few only of the potential cases of refractive anomaly. Perhaps it is not too much to say of some of these practical instructions, that they are totally and manifestly unsound. Scheffler has endeavoured to base a series of rules for the choice of spectacles on purely optical data, and we have no doubt that the consequences to medical science will be beneficial and numerous. This has been done especially for the English translation, which thus contains about seventy pages more than the German edition. One of the novelties in this volume is the elaborate account of the principles involved in the use of the orthoscopic spectacle-glasses, which are in some measure a combination of lens and prism. These were first suggested by Giraud-Teulon, but were not thoroughly worked out till Dr. Scheffler took the subject in hand. This book seems at first a little difficult to grasp; but if readers will only strictly attend to the simple laws of refraction, we see no reason why any thoughtful person should find the principles laid down at all unintelligible. At all events, it is no fault of Mr. Carter's if they do, for he has rendered the text as simple and as clear as was possible by his notes and explanatory remarks.

PREGLACIAL MAN.†

STUDENTS of prehistoric archæology will be disappointed if they expect to find anything to interest them in this work. The author, Mr. Moore, has put together, in the most irrational and confused fashion, the remarkable discoveries of geologists and physicists, with a view to show that the stone-record exactly corresponds with the Mosaic one as it is translated into English in the Bible. We must say that we cordially detest effusions of this kind, in which a little superficial scientific knowledge is united to a special pleading ingenuity. They are as painful to the really scientific man in search of religious truth as they are confounding to the general public and injurious to the best interests of theology. They serve no useful purpose, for they distort scientific fact, and they induce a most pernicious system of reasoning, compounded of the influence of extreme scepticism and equally

* "The Theory of Ocular Defects, and of Spectacles." Translated from the German of Dr. Hermann Scheffler. By Robert B. Carter, F.R.C.S. London: Longmans, 1869.

† "Preglacial Man, or Geological Chronology." By J. Scott Moore. Dublin: Hodges and Smith, 1868.

extreme credulity. When a Fellow of the Royal Geological Society of Ireland proceeds to discuss a geological question, and combines Croll's hypothesis and the acceptance of revelation-visions, we feel for the scientific body to which he belongs.

THE STUDY OF INSECTS.*

WE have already given a notice of Dr. Packard's excellent treatise on General Entomology (*Popular Science Review*, January). Since that notice was written, the fifth part has been issued, and we hasten to say a word or two about its contents. Part V. is fully equal in every respect to those which preceded it, both in illustration and typography. It continues the account of the Lepidoptera, but does not quite complete it. The descriptions are, as before, clear and terse, and the woodcuts, many of them original, are numerous and good. As might be supposed, the *Bombycidæ* occupy a considerable portion of the part; but other families, as *Sphingidæ*, *Papilionidæ*, *Noctualitæ*, and *Phalænidæ*, receive due consideration. We must repeat our commendation of this excellent treatise.

DISINFECTANTS.†

DR. ANGUS SMITH here reprints, with some additions, his report made to the Cattle Plague Commissioners. He has dealt with the whole subject of deodorisers and disinfectants on broad and scientific grounds; but he has hardly given us anything new, and he has not gone into the rationale of the action of these substances as thoroughly as is desirable. Still his volume will be very useful as a practical handbook and as a work of reference, and we think he did well to rescue his observations from the oblivion to which all "Blue books" are consigned.

LARDNER'S OPTICS.‡

THE student who desires to study physics in these days has really an "embarrassment of riches" in the abundance of manuals from which he may choose a text-book. Some years since Lardner's handbooks were much thought of; but the old editions are now behind the age, and therefore the

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* "A Guide to the Study of Insects." By A. S. Packard, Jun., M.D. Part V. Salem, U.S., 1869.

† "Disinfectants and Disinfection." By Robert Angus Smith, Ph.D., F.R.S., etc. Edinburgh: Edmonston and Douglas, 1869.

‡ "Handbook of Natural Philosophy." By Dionysius Lardner, D.C.L. "Optics." Edited by T. Olver Harding, B.A. London: Walton, 1869.

publisher has done well in bringing out a new series. The volume edited by Professor Carey Foster was devoted to magnetism and electricity, and was modified by him in accordance with the advance of scientific knowledge. The present volume, on Optics, has been entrusted to Mr. T. O. Harding; but the result in this case has, though good, been by no means so successful as in the former instance. The chapter on the eye, the microscope, and on photographic optics, are to our mind not at all what they should be, and give us the idea that the editor has more mathematical knowledge than general experience in matters optical and physiological. The following remarks, which he has introduced to give novelty to the old edition, will certainly be *new* to ophthalmic surgeons: "Since the rays of light which produce the sensation of different colours differ in wave-length, or, what is the same thing, since the vibrations they excite in the eye differ in rapidity, it follows that if the retina, whilst perceiving the existence of the vibrations, be unable to appreciate the difference of their rapidity, vision will be unimpaired as to form and position, but differences of colour will not be perceived. *Such a defect on the sensorium of the eye is fortunately rare, but not unprecedented.*" This is certainly a mild way of stating a defect so common, that candidates for situations as railway guards and engine-drivers have been so frequently found to display it, that they are now invariably put to the test as to their power of discriminating colours. Ophthalmologists know that this condition is by no means unfrequent. There are other parts of this book to which we object. Nevertheless, the volume is a sound one on the whole, and we can recommend it.

Tommy Try, and what he did in Science, by C. O. Groom Napier, F.G.S. Chapman and Hall, 1869. Tommy seems to have achieved so high a degree of scientific knowledge, at an age when most of the commonplace members of the British nursery still maintain an affectionate regard for lollypops, that we fear to push his biography beyond the point at which Mr. Napier's narrative commences. At this tender epoch of his existence, he had reached his seventh year, but he had already mastered the Linnean system of classification of plants, understood the laws of refraction of light, had been stung by a dead medusa, had distinguished the species from another, one also duly appreciated, and had experimented with mordants on the dyes of some "cryptogamic algæ." To pursue Tommy further, would really be to travel out of the domain of Popular Science; so Mr. Napier must excuse our leaving his young Crichton to other hands than ours.

Causeries Scientifiques, 1868. Paris: Rothschild, 1869. Is a year-book of scientific facts, and, like all such, is interesting and imperfect.

SCIENTIFIC SUMMARY.

ASTRONOMY.

TRANSITS of Venus in 1874 *and* 1882.—If the next pair of transits of Venus should fail to afford a satisfactory determination of the sun's distance, it will not be for want of due care on the part of our astronomers to prepare for the necessary observations. So far back as 1857 the Astronomer Royal called the attention of the scientific world to the requirements of each transit. He pointed out that the method which was pursued in 1761 and 1769 will be wholly inapplicable in 1874, and is embarrassed in 1882 with the difficulty of finding a proper station on the almost unknown Antarctic Continent. The recent publication of Leverrier's new tables of Venus, and of calculations founded upon them by the indefatigable Mr. Hind, have induced the Astronomer Royal to re-examine the whole subject. He has come to the conclusion that it will be unsafe to trust exclusively to the chance of securing observations on the southern continent in 1882; and that it will be desirable to make observations, both in 1882 and 1874, directed specially to the determination of the acceleration and retardation of the planet's ingress and egress, as affected by parallax. In order to understand the principle on which this method is founded, let the reader suppose himself placed at that point of the sun's surface where (as seen from the earth) first contact takes place, and that he watches from thence the passage of Venus across the earth. It is clear Venus would appear to him larger than the earth; the disc of Venus would come up to the edge of the earth's disc at a certain point and sweep across that disc, until at a point almost exactly opposite to the former the occultation would be complete. The process would last about ten minutes: the first point reached would clearly be that part of the earth's surface at which the ingress of Venus would take place earliest; the second would be the part where the ingress would take place latest. And it is obvious that if two observers were placed at these spots, one at each, and severally timed the moment of apparent ingress, the knowledge of the exact interval would be available as a means of determining the sun's distance. Similar considerations apply to the egress. In practice, the points we have named would not be available, because the sun, as seen from them, would be upon the horizon at the moment of ingress; but spots could be so chosen as to give a sufficiently large interval, and yet to allow the sun to be well raised above the horizon at the moment of ingress. So also for the egress.

As the absolute time of each phenomenon would require to be known, this method would not be available unless the longitude of each place of observation were known within a second or so. It is on this account that the Astronomer Royal calls the attention of men of science to the necessity of preparing for the coming transits by carefully ascertaining the longitudes of places suitable for the proposed observations.

Observation of the Transits of Venus by means of Photography.—Mr. Warren De la Rue, at the desire of the Astronomer Royal, has placed before the Astronomical Society a statement of the means by which photographic views of the sun taken at different places during the course of the transit, might be rendered available for the determination of the sun's distance. What would be required would be—1, the determination of the epoch of each photographic record; 2, proper corrections of the photographs for optical distortion; and 3, corrections (if experiment should suggest any) for shrinkage of the collodion. Mr. De la Rue proposes that six precisely similar instruments should be prepared and mounted equatorially, but without circles or driving clock, and sent to six convenient stations. The optical distortion of each instrument could be determined beforehand, and no further experiment would be necessary, as all the parts would be rigidly fixed.

Major Tennant's Photographs of the Great Eclipse.—For several months after the receipt of Major Tennant's telegram from India, announcing that six photographs of the sun had been taken, the scientific world had continued in suspense respecting their value. Major Tennant's letters had indeed rather tended to convey the notion that the photographs were comparative failures, than that he had been completely successful. It was, therefore, a pleasing surprise when, at a recent meeting of the Royal Astronomical Society, Mr. De la Rue announced that the photographs were eminently valuable and interesting. After all the care and expense devoted to the preparation of the expedition, and the skill with which Mr. Browning had overcome the difficulties attending the construction of the 9-inch Newtonian for photographing, it would have been a matter for regret had the expedition been rewarded with anything but complete success. We shall await the publication of trustworthy copies of the photographs taken at Aden before considering Major Tennant's photographs at length. One important point will probably be settled by the comparison of the two sets of photographs. From direct observations of a great pointed prominence which attracted the attention of nearly all the observers of the eclipse, it appears probable that during the interval between the earlier and later views, this prominence underwent remarkable changes of figure. As it is depicted in Major Tennant's photographs as an enormous spiral with convolutions diminishing in range from base to summit, it seems likely that processes of a remarkable character were at work at this part of the sun's surface. As Aden and Guntoor are so far apart, there is every reason for hoping that the indications of change will be sufficiently marked when the two sets of photographs are compared. Indeed, from a drawing in the *Engineer*, which purports to represent the aspect of this prominence as seen at Aden, it seems tolerably clear that such a change had taken place.

The Nebula in Argo.—It appears that, after all, there have been no such changes in this nebula as Mr. Abbott's communication had led the astrono-

mical world to suspect. Lieutenant Herschel, at his father's request, has carefully examined the nebula with the five-inch telescope (refracting), supplied by the Royal Society for the eclipse-observations. From his drawings it appears that the stars in the nebula have not shifted their places, and that the nebula itself, so far as can be judged from the comparison between views taken with an 18-inch reflector and with a 5-inch refractor, has a shape now very much resembling that which it had when Sir John Herschel was at the Cape. It is brighter, or seems to be so; but the change may partly be ascribed to the change of η Argûs (around which the nebula clings) from the first to the sixth magnitude.

Method of viewing the Solar Prominences without an Eclipse.—It is announced that Mr. Huggins has been successful in applying means to render the solar prominences visible when the sun is not eclipsed. If it should appear that the method is one which may become generally available, this discovery will be undoubtedly of extreme importance. Nothing seems now wanting for the determination of the exact nature and purpose of these singular objects except the means of watching the processes of change which they may be undergoing.

The Nebular Hypothesis of Laplace.—Professor Kirkwood, of America, has discovered some very singular relations in (1) the asteroidal system, and (2) the system of rings and satellites circling around Saturn. He takes a list of 97 asteroids, and having arranged them in the order of their distances, he examines those instances in which the gap between successive distances is considerably in excess of the mean interval. He finds that in every instance the gap corresponds to a mean distance such that an asteroid revolving at that distance would have a period commensurable with that of Jupiter. Thus, having first taken the 72 nearer asteroids (because the remoter, as more difficult of detection, require to be placed in a class by themselves), he finds that the mean interval between the first and the last of this set is 0·0081. The greatest gap in the order of distances occurs between Ariadne and Feronia, whose mean distances are respectively 2·2034 and 2·2654—so that the interval 0·0620 is nearly eight times the mean. Now a planet having a period equal to two-sevenths that of Jupiter would have a mean distance of 2·2569, which it will be seen lies between the two values given above. Again, the interval between the mean distance of Thetis (2·4737) and that of Hestia (2·5178) is 0·0441, or more than five times the mean; and a planet having a period equal to one-third that of Jupiter would travel at a mean distance of 2·5012. In the outer section, the mean interval is 0·0286. The greatest hiatus occurs between the mean distances of Undina and Freia (3·1917 and 3·3877), the breadth being 0·1960, or more than eight times the mean. A planet having a period equal to one-half that of Jupiter would revolve at a mean distance of 3·2776. And one or two other similar coincidences are noted. Undoubtedly this result is well worthy of notice: and if these researches should be confirmed when the number of known asteroids is very much increased, they would seem to point to a physical cause as the only possible explanation. As it is, the doctrine of chances is largely in favour of Professor Kirkwood's view that such a cause has been in operation. He points to the effect of commensurability of the sort considered, in causing disturbances in the motion

of a small planet. Extending this view to the particles supposed upon the nebular hypothesis to have been travelling in a sort of cosmical cloud around the space now occupied by the zone of asteroids, he shows how all the particles travelling in periods nearly commensurable with the period of Jupiter would be so disturbed as to take up eccentric orbits and so come into collision with outer or inner zones. Thus the zone they had belonged to would become vacant. Extending these considerations to the Saturnian ring-system, as affected by the nearer satellites, he shows how the theory supported in Proctor's "Saturn," that the rings consist of multitudes of small satellites travelling nearly in one plane around Saturn, would require (on his hypothesis) that there should be a division in the rings wherever the small satellites would have a period nearly commensurable with that of one of the large satellites. Applying this consideration to determine whether a physical cause can be assigned for the great division, he has detected the following very singular relation. The period of a satellite revolving at a distance equal to the inferior limit of the great division is 10 h. 52 m. 11 s., while that of a satellite revolving at a distance equal to the exterior limit is 11 h. 35 m. 18 s. Now, between these limits lie the following proportional parts of the periods of the four inner satellites—one-sixth of the period of Dione (10 h. 56 m. 53 s.), one-third of the period of Enceladus (10 h. 59 m. 22 s.), one-half of the period of Mimas (11 h. 18 m. 32 s.), and one-fourth of the period of Tethys (11 h. 19 m. 36 s.). Certainly these coincidences are very remarkable, and go far to establish Professor Kirkwood's interpretation of the gaps in the asteroidal zone, and of the general bearing of all such facts upon Laplace's nebular hypothesis.

The Lunar Crater Linné.—This crater is beginning to be a weariness of the soul to astronomers. The rival views respecting the supposed volcano in eruption at this point of the moon's surface have been maintained with equal energy and acumen by many of our best observers. But so much uncertainty hangs over the whole question at present that we may be permitted to look with less interest upon the discussion of opposite hypotheses, than we should feel if the indications of activity had been more satisfactory. Mr. Birt has been diligently engaged in examining the observations of Mr. Huggins, Captain Noble, Baron Mädler, Professor Tacchini, and others; and he has constructed a section of the crater, which appears satisfactorily to account for the phenomena which have been observed. He remarks, that if any changes are taking place in the surface round the orifice of the crater, these changes can hardly fail to be indicated by corresponding variations in the epochs of the disappearance and reappearance of the shadow after sunrise at the crater, and before sunset. In a letter to Mr. Birt, Baron Mädler remarks that the great whitish spot surrounding Linné, as shown in the English observations and in Tacchini's drawings, was never seen by him in 1831. The crater was then surrounded by the greenish colour of the Mare Serenitatis.

The Planets during the next Quarter.—Jupiter will be in conjunction with the sun on April 16, until which time he will be an evening star, though daily becoming less favourably situated for observation. Saturn is slowly returning to our nocturnal skies, and will be very favourably situated for observation from the end of May. His ring-system, being fully open, will

form an interesting subject of study to our telescopists. At present Mars is the only planet well situated for observation; he will continue to be a conspicuous object in our evening skies throughout the quarter. Venus is throughout the quarter very unfavourably situated, passing her superior conjunction on May 8.

BOTANY.

Difference between the Akazga and Strychnia Plants.—The distinction between these two is a matter of some importance to the physiological botanist, and it has been very clearly determined in a paper lately published by Dr. T. R. Fraser of Edinburgh, which he has been good enough to send us. In reference to the structure of the pith and wood-cells the differences are as follows:—In *Akazga,* the *pith* consists of complete parenchyma. Its cells have, in transverse section, a more or less regularly hexagonal form, and, in longitudinal section, they present the appearance of four-sided parallelograms. Their transverse diameter varies from $\frac{1}{500}$ to $\frac{1}{1500}$ of an inch, being usually, however, about $\frac{1}{800}$; while their longitudinal diameter is from $\frac{1}{40}$ to $\frac{1}{600}$ of an inch. The majority of the cells are indurated and marked by radiating canals. A few non-indurated cells occur irregularly throughout the pith, and these contain starch granules. The *wood-cells* have pretty constantly a diameter of $\frac{1}{2000}$ of an inch, and are greatly indurated, the cavity being so much reduced in size as to appear, in cross-section, like a point. Such a section also shows that the wood-cells are divided into regular four-sided groups; by numerous medullary rays, which vary greatly in thickness—some consisting of only one layer of cells, and others of three or four. In *Strychnos Nux-vomica,* the *pith* is only slightly indurated; and in the sections examined, its cells almost invariably contain starch granules; a very few nearly perfectly indurated cells are, however, present. These cells vary considerably in diameter, some being met with of $\frac{1}{2000}$ of an inch, and others of $\frac{1}{800}$. The majority of the smaller cells occur at the circumference of the pith. The *wood-cells* are of the same character as those of *Akazga.* The cylindrical tracts of delicate parenchyma are, however, larger, and much more numerous than those in *Akazga.*

Botanical Lectures at Cambridge.—The Botanical Professor will commence his course on Tuesday, April 13, in the south-western lecture-room of the museum, at 1 o'clock. They will be continued on Tuesdays, Thursdays, and Saturdays at the same hour. Gentlemen who wish to pass the special examination in botany for their degree must obtain a card from the registry; by them no fee is paid to the professor. The fee required of other students is one guinea each for this course of lectures.

The Preparation of Fungi.—At the meeting of the Botanical Society of Edinburgh on December 10, Mr. James English presented a paper on this subject. About three years ago he hit upon a method of preserving fungi, whic hhe then recorded. The process adopted is that of waxing the specimens, and thus preserving their natural pileus and stipe. Specimens preserved in 1866 are now as fresh as when first prepared. A series of fungi

thus prepared by Mr. English, and now in the Museum at the Royal Botanic Garden, were exhibited to the meeting.

Distribution of Aster salignus.—Miss Beever records the occurrence of this plant on the shore of Derwent Water, where it was collected by Miss Edmonds, in 1868, in flower. "This plant also occurs near Cambridge, and in several places on the banks of the Tay, between Dalguise and Seggieden. In one locality below Perth, Dr. White remarks that it is associated with several introduced plants, such as *Linaria repens, Petasites alba, Sanguisorba Canadensis, Mimulus luteus, Crocus vernus,* and *Narcissus Pseudo-narcissus,* which are all more or less common, and well established, along the banks of the river. In France, *Aster Novi Belgii* seems to hold the same place as *A. salignus* does in Britain—that of an exotic plant, well established on the banks of several rivers, as near Strasbourg, Laugre, and Lyons."

The Lichen Flora of Greenland has been explored by Dr. Lauder Lindsay. In a paper read before the Botanical Society of Edinburgh (January 14), Dr. Lindsay states that his attention has been drawn to the lichen flora of Greenland by being requested in the winter of 1867-8, by Mr. Robert Brown, to examine and determine the lichens collected by him in West Greenland in the course of the West Greenland Exploring Expedition of 1867. On studying, in connection with the determination of the species so submitted, the literature of Greenland lichenology, he was surprised to find that there was no recorded modern list of the lichens of that country. Accordingly, he had drawn up a list of all the lichens which to the present day had been found, or recorded to have been found, in Greenland, compiled from all the sources of information accessible to him. The list included 268 species and varieties.

Tinting Vegetable Tissues.—At the meeting above referred to, Dr. W. R. M'Nab described the results of his recent attempts at staining tissues with various dyes. He mentioned a large series of experiments he had made by staining certain microscopical structures with acetate of mauvine and Beale's carmine solution. He showed that by means of staining, the high powers of the microscope can be used to bring out points of structure not easily demonstrated without being so treated. The process of staining does not seem to be attended with any great difficulty, and the author believes that very important results may be obtained by careful study of its action on germinating plants.

Greenland Diatomaceæ.—Professor Dickie, who has recently examined the collection made by Mr. Robert Brown, says that all the species were British with the exception of *Hyalodiscus subtilis*, originally described by the late Professor Bailey, from Halifax; found also on the shores of North-West America, and now on the shores of Greenland.

Death of two eminent Botanists, Von Martius and Schnitzlein.—Dr. Philipp von Martius died at Munich on December 13, 1868, at the age of seventy-five. He was born at Erlangen, and prosecuted the study of medicine at that university, and was a contemporary of Theodore Nees von Esenbeck. He was for a long time Professor of Botany in the University of Munich, and director of the Botanic Garden. He is well known for his large and splendid work on Palms, and his works on the geography and natural history of Brazil. He published a *Flora Brasiliensis,* and numerous other works and

papers.—Dr. Schnitzlein died on October 24, 1868, at the age of fifty-five. He had suffered for upwards of four months from an accident which he met with while botanising on the Tyrol. He was Professor of Botany at Erlangen, and director of the Botanic Garden. His chief work is the "Illustrations of the Natural Families of Plants" (*Iconographia Familiarum Naturalium Regni Vegetabilis*), which, unfortunately, is not completed.

The Colour-reactions of Lichens.—It has recently been asserted by the Rev. Mr. Leighton and by Herr Dr. Nylander that the chemical reactions of lichens afford a clue to their specific qualities. This assertion, however, receives very distinct denial from Dr. Lauder Lindsay, who has given considerable attention to the subject. The various experiments conducted by Dr. Lindsay lead him to the following conclusions:—1. The same specimen, in the hands of the same operator, in its different parts, at different times, frequently exhibits colour-reactions different at least in degree. 2. The same species, in the hands of the same operator, and, still more so, in those of different experimenters, in different specimens from the same or different localities, differing in freshness of collection or age, occurring in different varieties of forms, or in different conditions of growth (fertile or sterile, hypertrophied or degenerated), frequently shows colour-reactions differing equally in kind and degree. 3. Colorific quality is determined by circumstances (not fully understood) connected with (*a*) locality of growth in relation to climatic, geographical, topographical, geological, or other conditions. (*b*) States of development, in relation to sterility, hypertrophy, or degeneration of the vegetable tissues proper. 4. This inconstancy of colorific property leads the archil manufacturer never to depend on laboratory testings in the purchase of his "orchella weed," or in determining its commercial value; for it not unfrequently happens that a most promising *Roccella* even proves worthless, and is, as such, cast aside. 5. Colour-reaction, though interesting in itself in connection with the general subject of lichen colorific or colouring matters, affords *no aid that can be depended on*, either (*a*) to the systematist in defining species, or (*b*) to the dye manufacturer in determining the value of his "orchella weed."—*Scientific Opinion*, March 3.

How to Bleach Wood Pulp.—This is a question of some importance in relation to the manufacture of a certain form of paper, and it is answered by a French chemist in a paper in a recent number of the *Revue de Chimie*, which appears in abstract in the *Journal of the Society of Arts*. M. Ouvli states that chloride of lime, if it happens to be in the slightest excess, has a tendency to give a yellow tinge to the pulp; that all energetic acids, without exception, tend to give a reddish colour to the paper when exposed for a long time to the effects of the sun or of moisture, and that the least trace of iron is sufficient in a very short time to blacken the pulp. He says he has succeeded in avoiding all these inconveniences by the use of the following mixture:—For a hundredweight of wood-pulp, he employs 400 grammes (four-fifths of a pound) of oxalic acid, which has the double advantage of bleaching the colouring matter already oxidised, and of neutralising the alkaline principles which favour such oxidation; he adds to the oxalic acid one pound, or a little more, of sulphate of alumina, entirely deprived of iron. The principal agent in this mode of bleaching is the oxalic acid, the

power of which over vegetable colouring matters is well known; the alum has no bleaching power of its own, but it forms with the colouring matter of the wood an almost colourless lake, which has the effect of increasing the brilliancy of the pulp.

Cultivation of Cinchona in India.—It appears from Dr. Anderson's report on the number and distribution of Cinchona plants in the Government grounds at Darjeeling on 1st September last, that the cultivation of bark progresses. The total number in the various plantations at that date was 2,075,078—viz. *C. succiruba,* 1,118,557; *C. Calisaya,* 20,354; *C. micrantha,* 29,667; *C. officinalis* and vars., 901,408; *C. Pahudiana,* 5,092.

The Microscopical Structure of the Brazil Nut has been lately investigated by Professor Dickson, who has resigned the chair of Botany in Trinity College, Dublin.

Microscopic Fungi.—The forms of fungi which are assumed to have relation to cholera have formed the subject of a series of papers in the *Lancet* (January 2, 9, and 16). The papers constitute a series of reports by Drs. Lewis and Cunningham on the results of their interviews with MM. De Bary, Hallier, and Piltenkofer. The conclusions arrived at were rather vague and extremely discordant.

The Vitality of Desmids.—Dr. Wallich, in a note on the Desmidiaceæ of Greenland, points out the extraordinary vitality of these plants. Botanists fancy that the resistance to the conditions of death, which the diatom possesses is due to its coat of silex; but Dr. Wallich gives instances where, in Greenland, in the midst of melting ice, even desmids grow abundantly. "In July," he says, "the specimens were certainly somewhat inferior to those of similar species met with in more genial climates. But, otherwise, as regards luxuriance of growth, the rate and extent to which the paradoxical multiplication by division appeared to be taking place, and the brilliance of the green colour of the chlorophyll, there was no inferiority whatever. The period of the year was the middle of August, when, during two or three hours, about mid-day, the sun's heat is very great, even in these boreal latitudes; but this only makes the circumstance the more wonderful, inasmuch as the temperature, for at least twenty out of the twenty-four hours, is very low indeed."—*Monthly Microscopical Journal,* February, 1869.

The Morphology of Leaves.—In a paper having the title of the "Composite Structure of Simple Leaves," Mr. John Gorham states that he conceives that a philosophical morphology can be founded on an examination of adult leaves, and of the metamorphosis which certain leaves occasionally undergo. The type of all leaves is, he thinks, to be found in the simple leaf. Of the four or five simple leaves described in botanical works, he thinks there are two which demand special attention; these are, the true *netted* leaf and the feather-veined leaf. These two, he believes, enter into the composition of almost all compound metamorphosed and simple-lobed leaves. Mr. Gorham's paper is one of considerable length, and although it leaves the main point—that of development—untouched, it is of much interest.—Vide *Monthly Microscopical Journal,* March, 1869.

Bacteria in the Protoplasm of Plants.—This fact has been already, as pointed out in one of our recent numbers, well established. The question,

as to how the bacteria became developed in these situations, however, is a point by no means so well determined. It is to this problem that M. Béchamp has directed his attention, and to which he endeavours to reply in the *Comptes-Rendus* of February 22, 1869. M. Béchamp states his belief that the reason why these organisms are found in the cells of plants is that the plants themselves contain the germs of bacteria in the so-called microzymas which enter into their own constitution. He describes a number of interesting experiments on foreign plants, and then tabulates the following conclusions:—(1) Bacteria may easily be developed even in acid solutions. (2). The normal microzymas of plants, like those of animals, may readily become evolved into bacteria. (3). It is likely that when plants are inoculated with bacteria, these bacteria do not continue either to live or propagate. (4). Previous observations on spontaneous generation have overlooked the existence of the small molecular bodies (the *microzymæ*). With reference to this last conclusion of the author's, we must remark that it is quite a gratuitous assumption. Dr. Hughes Bennett, and also Pouchet and others, admit the existence of the molecular basis, though they may not admit its power of movement. M. Béchamp's paper appears elsewhere in our pages.

CHEMISTRY.

The Derivatives of Benzine.—In a paper lately read before the Royal Academy of St. Petersburg, M. Zinin stated that, while pursuing his researches on the derivatives of benzine, he found that chlorobenzile is easily attacked by reducing agents, and that in its alcoholic solution it is transformed into desoxybenzine by the action of zinc and hydrochloric acid. The reaction is thus expressed:—

$$C_{14}H_{10}OCl_2+H_2-Cl_2=C_{14}H_{12}O.$$

The product obtained is almost pure, and exempt from all foreign matter.—Vide *L'Institut*, March 10, 1869.

The Varieties of Graphite.—M. Berthelot, who has been recently giving much attention to this important subject, has published some of his conclusions in the *Comptes Rendus*; and our contemporary the *Chemical News* (March 5th) has given a translation of them. M. Berthelot describes the following process for separating these several forms of graphite: Mix with the powdered carbon five times its weight of chlorate of potassium previously pulverised, and gradually form into a sort of paste with fuming nitric acid; leave it for some hours in a small open flask, and then heat it for three or four days without intermission to about 50 deg. or 60 deg. C.; after this dilute it with water and wash by decantation with tepid water until the salts of potash are dissolved. This will give the following results:—1st. In the case of a mixture of amorphous carbon and diamond, the amorphous carbon is entirely dissolved after a few repetitions of the process, while the diamond remains unaltered. 2nd. In a mixture of graphite and amorphous carbon, the amorphous carbon is completely dissolved after repeated treatment, whilst the graphite gives rise to an insoluble graphitic oxide of a

yellow or greenish-yellow colour, decomposable with deflagration. The graphitic oxide may be decomposed, as will be shown, in such a way as to cause the disappearance of the whole of the carbon. 3rd. In a mixture of diamond, graphite, and amorphous carbon, the amorphous carbon is entirely dissolved, leaving a mixture of graphitic oxide and diamond. This cannot be dissolved by solvents, but the diamond may be isolated as follows: Dry the mixture; then heat in a tube closed at one end. The graphitic oxide is destroyed, leaving pyrographitic oxide. This, reoxidised by chlorate of potash and nitric acid, forms soluble products, and a proportion of graphitic oxide much smaller than that first destroyed. On decomposing this new graphitic oxide by heat, and then reoxidising the new pyrographitic oxide, only traces of graphitic oxide will be discovered. After three or four operations the whole of the graphitic oxide will disappear, leaving only the diamond.

Detection of Mercury in Cases of Poisoning.—This is a point of much importance to medical men and to professional toxicologists. The following method was recently employed by M. Buchner in a case of poisoning with corrosive sublimate. The organic remains having been disintegrated by a hot mixture of chlorate of potash and hydrochloric acid, the solution was diluted and saturated with sulphuretted hydrogen. After the lapse of some hours, the sulphide formed was collected, dissolved in aqua regia, and reduced by evaporation to a small volume. A little water being added, a bright piece of copper wire is placed in the liquid; and when mercury is present the wire becomes grey, at the latest, in two days. The copper is withdrawn, dried between folds of blotting-paper, and heated in a wide test tube. The mercury is more easily distinguished by removing the wire, and placing in the tube a drop of tincture of iodine. M. Riederer, having remarked that the sulphide of mercury which is formed by this process always contains organic matter, has recourse to dialysis. He operates in the following manner. After disorganisation by chlorate of potash and hydrochloric acid, the mercury in solution is precipitated by sulphuretted hydrogen, the sulphide collected dissolved in a mixture of chlorate of potash and hydrochloric acid, and dialysed with 500 c.c. of water. At the end of five days, the water is evaporated and the dialysis repeated. After this treatment, the solution is again saturated with sulphuretted hydrogen; the precipitate is washed with ammonia and sulphide of ammonium, then with weak nitric acid, and finally treated afresh with hydrochloric acid and chlorate of potash. Operating upon dogs with calomel, M. Riederer has recognised that the greater part of the mercurial compound is eliminated by the excrements, and that, for the rest, more collects in the liver than in the muscles.—Paris correspondent of *Chemical News*, January 15th.

How to prepare Nitrogen.—According to a recent number of *Cosmos*, a new method for this purpose has been devised by Signor Levy. He heats bichromate of ammonia, by which means he changes it into green sesquioxide of chromium, with evolution of water and nitrogen.

Action of Sulphate of Alumina on Turbid Water.—The *Photographic News*, quoting the *Technologist*, states, what is already well known to chemists, that, whatever be the nature and quantity of the earthy substances held in suspension in turbid water, it becomes fit to drink

in from seven to fifteen minutes if to each litre there be added ·04 grammes of finely-powdered alum, care being taken to agitate the liquid when the alum is introduced (this is about ¾ lb. per ton of water). If potash alum is used, the alum is decomposed into sulphate of potash (which is all dissolved by the water) and sulphate of alumina, which, by its decomposition, purifies the water. The alumina separates in an insoluble form, and carries down with it, as it precipitates, the matters which render the water turbid, and the organic matter. The acid attacks the alkaline and earthy carbonates, and transforms them into sulphates. The water becomes slightly richer in bicarbonates and free carbonic acid, whilst all organic matter is destroyed. Seven parts of sulphate of alumina will purify as much water as ten parts of rock alum or potash alum, and the sulphate of alumina does not introduce any alkaline sulphate into the clarified water.

Antidote to Phosphorus.—It is asserted by a writer in one of the late numbers of the *Bulletin de Thérapeutique* that turpentine is a very useful antidote in cases of phosphorus poisoning. What is the explanation of this quality?

The Determination of Nitrous Acid.—In a paper recently laid before the French Academy, M. Chabrier, who has been studying the different oxides of nitrogen, gives these two conclusions:—(1) in liquids containing at the same time nitrites, nitrates, and organic matter, the nitrous acid of the nitrites may be determined by the decolorising action which hyposulphite of soda exerts on the iodide of starch, produced by the reaction of the nitrites on iodide of potassium, in presence of starch and dilute sulphuric acid; (2) in the absence of nitrates and organic matter the determination can be more easily made by the decoloration of indigo solution, operating with the aid of heat, but out of contact with the air.

The Purification of Metallic Bismuth.—In the *Pharmaceutical Journal* for January, Mr. C. H. Wood states that the officinal process for the purification of bismuth is in accordance with the method indicated by most chemical authorities. Gmelin, Watts, and other authors state that the impurities of bismuth are removed by fusion with nitre. Schacht's experiments sufficiently demonstrate the possibility of removing the whole of the arsenic by this means. It is true, says Mr. Wood, that, in some fusions, Schacht found a portion of the arsenic still remained in the metal; but we are not informed what the proportions were before and after, and we have every right to assume that, by continuing or repeating the process, the whole might have been removed in these as in the other cases. His own experiments have sufficiently satisfied him that the Pharmacopœia method is an efficient one for the complete removal of arsenic, antimony, and sulphur. The most careful application of Marsh's test has failed to detect either of the former substances in any sample of the metal he has purified.

The Preparation of Cerium.—A note in the *Scientific American* for February gives the following as the mode of preparing this metal adopted by Wöhler:—A solution of the oxide in hydrochloric acid is mixed with equal parts of chloride of potassium and chloride of ammonium, and evaporated to dryness, fused, and poured out to partially cool, and then coarsely pulverised and mixed while still warm with pieces of sodium, and the whole projected into a clay crucible previously heated to redness. In this manner the cerium is reduced, and appears in the slag in the form of two pellets, which can be collected and fused into one mass.

The Chemical Properties of Nitro-Glycerin have been thus defined by M. F. Tilberg. Nitro-glycerin (from the works at Stockholm) is decomposed when acted upon by potassium hydrate; amongst the products of decomposition are potassium nitrate, glycerin, ammonia, cyanogen, oxalic, humic, and nitrous acid. When ignited in a vacuum with copper oxide and copper, two volumes of carbonic anhydride and one volume of nitrogen are obtained, from which numbers the formula $\Theta_3H_5(N\Theta_2)_3\Theta$ is deduced. Nitro-glycerin dissolves in concentrated sulphuric acid, forming with it a new compound acid which yields crystalline salts. A combustion gave three volumes of carbonic anhydride to one volume of nitrogen. If nitro-glycerin is regarded as a substituted glycerin, and the relation between it and the new acid the same as that between glycerin-sulphuric acid and glycerin, the new compound will be dinitro-glycerinsulphuric acid.—*Oefvers. af Akad. Förh.*, 1868, 25, No. 2, 75; and *Journal f. Ch.* cv. 254; and *Chemical News*, Jan. 8.

Preparation of Ellagic Acid by means of Gallic Acid.—By heating (says M. J. Löwe, in the *Chemical News*, Jan. 22) nearly to the boiling-point for several hours in an aqueous solution of two equivalents of gallic acid and one of arsenic acid, a crystalline precipitate is deposited, which is none other than ellagic acid; the best way is to mix the two acids in the proportion indicated above, add water, evaporate to dryness, heat in an air-bath to 120° and extract with alcohol at 90°, which does not dissolve ellagic acid. The reaction is the following—

$$C_{28}H_{12}O_{20} + 2O = C_{28}H_6O_{16} + 6HO.$$

In commercial tannin there is always gallic acid, and consequently ellagic acid proceeds from it. A cold extract of oak bark gives by degrees a yellow deposit of ellagic acid, and it is, indeed, this same acid which constitutes that gelatinous covering which is formed over tanned hides.

Extraction of Sugar from Molasses.—At a recent meeting of the French Academy M. Dumas exhibited some crystals of sugar extracted by a process of M. Margueritte's from molasses. M. Margueritte has been enabled to extract from 100 kilogrammes of molasses 35 to 38 kilogrammes of true sugar, which brings up the total product of the beet-root to 25 per cent. M. Margueritte treats the molasses by alcohol at 85 degrees, which dissolves the sugar. He also obtains a supersaturated solution of sugar. By projecting powdered sugar into this solution it crystallises, and nearly double the weight of sugar introduced into it is obtained from it. This sugar only contains one-hundredth part of impurity, and can consequently be immediately subjected to the refining process.—Vide *Comptes-Rendus*, Feb. 21.

Carbonic Acid decomposed by Plants.—From a large number of experiments recently made, M. Boussingault concludes that the chlorophyll is the agent of decomposition, and he states that wherever the chlorophyll exists it has the power of decomposing carbonic acid.

The Chemical Food of Plants.—In the *Comptes-Rendus* (March 1) M. Péligot has a note on the employment of sea-salt in agriculture which relates to this subject. M. Péligot thinks that scientific agriculturists labour under delusions in reference to the action of salt; he believes that in the case of impermeable soils, through which water passes slowly, the influence of salt is more hurtful to crops than beneficial. Analyses have shown him, con-

trary to the received opinion, that soda is present in the ash of plants to a far slighter extent than is generally believed. Most cultivated plants have no soda in their ash even when grown upon a soil rich in this salt. M. Péligot is opposed to the notion that chloride of sodium undergoes a change in the soil by which it first becomes carbonate and then nitrate. In fact, the only use of salt which he recognises is that due to its antiseptic action, by which it retards the decomposition of ordinary manures. This he thinks is why English farmers add it to guano.

Phenyl-bichloracetic Acid.—The last *Bulletin* of the Royal Academy of Belgium contains a paper on the relations of atoms in chemical molecules, in which the author gives the following mode of preparing the above substance: "In a flask of three litres capacity I place 24 grammes of phenyl-monochloracetic acid. I fill the flask with dry chlorine, and, having sealed the mouth hermetically, I expose it to the heat of the sun. After five or six hours the colour of the chlorine disappears, and I then open the flask and allow the dry chlorhydric acid to escape. The new body, washed with cold water on a filter, is then transformed into a soda salt, and the solution of this salt is decomposed by pure chlorhydric acid. It precipitates an oily liquid which partly solidifies, while the supernatant liquid becomes filled with quadrangular plate-like crystals. These crystals are carefully removed, dried with bibulous paper, and recrystallised from ether."

M. Dumas' Lecture in London.—The Chemical Society has invited M. Dumas to lecture to us in his own language. The lecture will probably take place in May, and at the Royal Institution. The subject is not yet announced.

The Hydrogen Flame Colour on Porcelain.—The blue colour produced when a jet of hydrogen is allowed to play against a piece of porcelain has been explained in a note recently published by M. Sallet. He says it is due to the presence of sulphur in the form of sulphate of soda in the atmosphere. If we mistake not, Mr. W. F. Barrett suggested this explanation two years ago.—Vide *L'Institut*, February 15.

Estivating Sulphur.—A note has been published by M. Lefort, who states that he uses aqua regia in the solution and determination of sulphur. He describes the action of aqua regia on sulphur to be, firstly, the formation of chloride of sulphur; secondly, the destruction of this compound by nitric acid or its derivatives; and consequently the regeneration of the chlorine, the evolution of nitrous vapours, and the formation of sulphuric acid. In proportion to the amount of nitric acid present, is the solution of the sulphur quickly arrived at. The most convenient mixture of hydrochloric and nitric acids for dissolving sulphur is made with one volume of the former and three of the latter.—Vide *Chemical News*, February 12.

GEOLOGY AND PALÆONTOLOGY.

The Dinornis in New Zealand.—Dr. Julius Haast lately sent a paper on the remains of the Dinornithic birds in New Zealand to the Academy of Sciences of Berlin. Dr. Haast stated that the deposit in which most of the

bones were found was at a depth of 30 ft. from the surface. From this and some other facts he concluded that the different species of Dinornis existed in New Zealand before, during, and after the great Glacial Period, and that in point of fact these birds, which had conquered external conditions, were only extinguished by man.

The Wollaston Gold Medal and Donation Fund of the Geological Society has been awarded to Mr. H. C. Sorby. At the annual meeting the President, Professor Huxley, referred especially to Mr. Sorby's researches into the structure of rocks and minerals, and of meteorites; and to his explanation of the phenomenon of slaty cleavage, now universally adopted, and fully in accordance with the results obtained by physical investigators who have approached the same question from a very different side. The balance of the proceeds of the Wollaston Donation Fund has been presented to Mr. W. Carruthers, F.G.S., of the British Museum, in aid of his researches in fossil botany; the President in handing it to Mr. Carruthers remarking, especially with regard to his researches on the structure of fossil fruits, that these are so valuable that Mr. Carruthers might justly look upon the award as an expression of gratitude for his labours. At the same time, Prof. Huxley observed that scientific gratitude was of the kind which had been defined as a lively sense of favours to come.

Geological Survey of Ohio, U. S.—It is intended to introduce a bill into the American House of Representatives to provide a thorough and new geological survey of the state of Ohio. The former survey was made by Colonel Charles Whittlesy, Colonel J. W. Foster, Professor J. P. Kirtland, Dr. C. Briggs, Professor W. W. Mather, Professor John Locke, and Dr. S. P. Hildreth. The last three named of the above are dead.

The Geology of China forms the subject of a communication made to the Geological Society (Dec. 23) by Mr. T. W. Kingsmill. The sedimentary deposits of the south of China were described as commencing at the base with a series of coarse grits and sandstones, having a thickness of about 12,000 ft., and overlain conformably by limestones and shales (with coal in the lower part), attaining a thickness of between 6,000 and 8,000 ft. The whole of these rocks were described by the author as the "Tung-ting series." In the Nanking district this formation is succeeded by sandstones, grits, and conglomerates, which the author has grouped together under the name of the "Chung-shan series." Its uppermost member contains beds of coal, and possesses an unknown thickness; but the remaining beds are together about 2,400 ft. thick. Mr. Kingsmill described in detail the geological relations and geographical extension of these rock-masses; he then gave a sketch of the superficial deposits, which occupy an important position in the geology of China, and from the older of which Mammalian bones and teeth have been obtained; and he concluded by stating that he had been uniformly unsuccessful in his frequent searches for traces of Glacial action.

Palæontology of the Alpina Tertiaries.—Herr Reuss, in the second part of the great work which he lately presented to the Royal Academy of Vienna, deals with the Actinozoa and the Bryozoa of the Crosara beds. The beds belong to a lower geological horizon than the coral-beds of Castel-Gomberto. In the strata marked No. 1, he has found but a few isolated corals of the genera *Trochocyathus*, *Acanthocyathus*, *Flabellum*, and *Trochosmilia*. There

are also two species of Eschara, though these are generally in a badly-preserved state. Those marked No. 2 abound in compound corals, some of them of very considerable size. The following families predominate:—*Calamophyllidæ*, *Symphyllidæ*, *Astreidæ*, *Thamnastreidæ*, and *Fongidæ*. Forty-nine species were determined; and of these eighteen belonged to Castel-Gomberto district. They were associated with numerous Bryozoa, especially species of *Lepralia* and *Membranipora*.

Is Eozoon a Mineral Production?—Professors Rowney and King have again raised this question and answered it in the affirmative, in a paper laid before the Geological Society of London. It was found when the paper had been read that all the microscopists who were present differed from the conclusion of the authors. Dr. Carpenter's observations, which we reproduce, strongly supported the opinion he has formed of the animal nature of Eozoon. Dr. Carpenter said that he need not repeat the grounds on which he regarded this as an organic structure. He objected to criticisms unless founded on examination of actual specimens. Sir William Logan had been first led to regard the Eozoon as organic by finding alternations of calcareous and siliceous layers in various minerals. A specimen which Sir William had brought from Canada contained much iron, and had the canal system wonderfully preserved; and it presented this character, that the larger branches were infiltrated with serpentine, and the middle branches with sulphide of iron, while the smallest branches were filled with carbonate of lime, of the same nature as the matrix. It was only under a favourable light that these smaller tubes were visible, as the calcite in them was of the same crystalline character as the surrounding network. This was conclusive evidence of the structure not arising from the mere infiltration of one chemical substance into another. Moreover, this foreign matter could not penetrate the cleavage-planes. When cut, some specimens had given out a strong odour of musk, which they to some extent still retained. This, again, seemed to be evidence of organic origin. He regretted that Professor King had not examined the large collection of specimens in his (Dr. Carpenter's) collection. Recent Foraminifera, when decalcified, exhibited precisely the same asbestiform layer round the chamber-cast as the fossil Eozoon. Different genera of Foraminifera in recent seas were infiltrated by different minerals, which presented some analogy with the condition of the fossil under consideration. In the great seas of the present day, at various depths and temperatures, was a large extension of sarcodic substance, and in this there were Rhizopods with and without shells, but of similar low structure; and such forms might have continued in existence through any length of time, so that the occurrence of Eozoon so far down as Jurassic times could afford no matter for surprise. He would not be astonished even if such a structure as Eozoon were found in deep-sea dredgings of the present day.

The Relations of Lepidodendron.—Some time since M. Brongniart discovered a fossil cone containing both microspores and macrospores, and showed that it belonged to a plant of the Carboniferous epoch. It has long been supposed that *Lepidostrobus* was the fructification of *Lepidodendron*, but no further evidence of the fact had been adduced than that which Dr. J. D. Hooker, F.R.S., had given by finding the cones in the insides of *Lepidodendron*

Harcourtii and *elegans*, which could only be considered of a very unsatisfactory nature. In a cone in Mr. E. W. Binney's possession in every respect similar to the late Dr. Robert Brown's celebrated specimen of *Triplosporite*, but having the column in a more complete state of preservation, there is most conclusive evidence from internal structure that the *Triplosporite* is the fruit of *Lepidodendron Harcourtii*, the pith vascular cylinder, vascular bundles communicating with the leaves or scales, and the outer cylinder being the same in the cone as in the stem, thus justifying Mr. Carruthers' opinion that the cone was a *Lepidostrobus*. The large spores found in a *Lepidostrobus* described by Dr. Hooker in the second volume of the *Memoirs of the Geological Survey*, as well as similar specimens found by the author in coal at Wigan, and described in the *Quarterly Journal of the Geological Society* for May 1849, are most probably both macrospores of the fructification of *Lepidodendron*, and have come from the lower portion of a cone, whilst Dr. Browne's were from the upper part. The same may be said of Professor Morris's specimen belonging to Mr. Prestwich, from Colebrook Dale, described and figured in vol. v. of the *Transactions of the Geological Society*, published in 1840, which clearly came from the lower portion of a cone of *Lepidodendron*. In the new genus *Flemingites*, described and figured by Mr. Carruthers in vol. ii. of the *Geological Magazine* for October 1865, there are two kinds of sporangia; those in the upper part of this long and slender cone being something like the sporangia of the *Lepidodendron*, but arranged in whorls and probably filled with microspores, whilst the lowest scales supported sporangia containing macrospores. This Mr. Binney gathered from much more perfect specimens than those which Mr. Carruthers had to work upon. Most certainly the little flattened discs which he described as sporangia are found on scales at the base of the cone, and not in the middle or upper portions of it, as many of the other specimens clearly prove. When Professor Brongniart's paper is published and drawings of his specimens are given we shall, in Mr. Binney's opinion, be better able to understand the relation of the genus *Flemingites* to *Lepidodendron*.—Paper read by Mr. Binney before the *Manchester Literary and Philosophical Society*.

The Red Chalk of Hunstanton.—In a paper before the Geological Society the Rev. T. Wiltshire described the section exposed in Hunstanton Cliff as showing:—1. White chalk with fragments of *Inocerami*. 2. White chalk with *Siphnoia paradoxica*, having its base undulated and the cavities filled up with a thin bright-red argillaceous layer, resting upon (3) the red chalk, which is divisible into three sections—*a*, hard, containing *Avicula gryphæoides* and *Siphonia paradoxica*, and with fragments of *Inocerami* at its base; *b*, hard, rich in *Belemnites*; *c*, incoherent at its base, rich in *Terebratulæ*. 4. Carstone, a yellow, coarse, sandy deposit, resting on a bed of clay, containing no fossils in its upper part, but with a band of nodules containing *Ammonites Deshayesii* and other species about thirty feet down, together with ironstone nodules like those of the lower greensand of the Isle of Wight, and bearing impressions of fossils which correlate the lower part of the carstone with the base of the English lower greensand. The author gave a list of these fossils, and also of those of the red chalk, the latter amounting to sixty-one, and presenting a mixture of forms belonging to the lower chalk, upper greensand, and gault. On comparison with the gault

section at Folkestone, the author considered it evident that the red chalk of Hunstanton was equivalent to the upper part of that formation. He mentioned that ten miles south of Hunstanton, in artificial sections, blue gault has been found resting upon the carstone, whilst rather nearer to Hunstanton the same place was occupied by a red clay, connecting the two dissimilar deposits; which, however, were shown by analysis to contain nearly equal quantities of iron. If the upper greensand be represented in the Hunstanton section, the author considered that its place must be in the band numbered 2, containing *Siphonia paradoxica* and *Avicula gryphæoides.*

The Recent and Fossil Beaver.—Professor Owen states that a recent examination of the bones of *Castor* and *Trogontherium* confirm his conclusion that the latter is "an extinct sub-generic type" of Castoridæ. He has given some very good drawings of the bones of the *Trogontherium.* Vide *Geological Magazine,* February.

"*Man and the Mammoth*" is the title of a very interesting paper in the above-mentioned journal, by Mr. Henry Woodward, F.G.S.

Hyperodapedon.—Professor Huxley has given the following description of this extinct lacertilian reptile:—"The head presents indications of a bone forming a second zygomatic arch on each side; the upper jaw is produced and bent downwards, forming a strong beak; and the lower jaw is produced on each side of the symphysis into a pointed process, between which the decurved beak of the upper jaw is received. The maxillary and palatine teeth are arranged in rows, and present some resemblance to the large nails in the sole of a boot; they are inserted on each side of the upper jaw upon the sloping sides of a deep grove, and are worn down and polished by the action of the mandibular teeth, which form a continuous and very close single series along the upper edge of the mandible. This peculiarity of arrangement enables the teeth of *Hyperodapedon* to be recognised wherever they may occur. The vertebræ have their centra slightly concave at each extremity. The other known parts of the skeleton are the ribs, scapula, coracoid, and part of the humerus, the pelvis, femur, and proximal ends of the tibia and fibula, and the abdominal false-ribs, which are largely developed in this reptile."

The Officials of the Geological Society.—The following list of changes has been published:—1. Mr. Henry M. Jenkins, F.G.S., who has for the past six years filled the post of Assistant Secretary, has been appointed to the position of Secretary and Editor to the Royal Agricultural Society of England. Mr. W. S. Dallas, F.L.S., who, during the past ten years, has been the Curator to the Yorkshire Philosophical Society's Museum at York, has been elected to the post of Assistant Secretary, Librarian, and Curator, in the room of Mr. Jenkins. 2. Mr. Skertchly, the Library Assistant, has resigned, in order to accompany Messrs. Bauerman and Lord to Egypt. Mr. Frederick Waterhouse, second son of G. R. Waterhouse, Esq., Keeper of the Geological Department, British Museum, has been elected in Mr. Skertchly's stead.

A Sandstone in course of formation was described by Mr. James Haswell at the meeting of the Edinburgh Geological Society, on January 21. This sandstone occurred at a point in the section of the Carboniferous strata between Elie and St. Monance, near the railway bridge at Ardross. Resting upon the Carboniferous strata was a bed of tenacious clay containing recent

shells, above which was blown sand, which was washed down by the rain over the clay, and deposited in ledges formed by the projecting beds of shale, while the siliceous particles of which the sand was composed were cemented together, partly by carbonate of lime held in solution by the rain water, and derived from the shells occurring in the sand and in the clay, and partly from a ferruginous cementing material contained in the latter. A hard sandstone was being formed, not unlike one of much older date, in some places enclosing one or two recent shells, thus making the resemblance more complete.

A new Cycadean fruit has been described by Mr. W. Carruthers, who has given it the name of *Beania*, in honour of Mr. Bean, the successful explorer of the fossiliferous beds of the Yorkshire Oolites. Mr. Carruthers' attention was drawn to the specimen (in the Bean collection) in the British Museum by Mr. Henry Woodward. It is from Phillip's "Upper Shale" at Scarborough. It is not associated with any Cycadean remains on the small slab on which it occurs, so that there is no indication to which of the several leaf species it belongs. A small fragment, however, of *Acrostichites Williamsonis* occurs on the slab.—Vide *Geological Magazine*, March.

MECHANICAL SCIENCE.

Concrete Arch.—A remarkable experiment in the use of concrete has been made on the Metropolitan District Railway. Over one of the cuttings an arch of concrete has been constructed, of 75 feet span, 7½ feet rise, and 12 feet width, resting on concrete skewbacks. The thickness of the arch at the crown is 3½ feet and the thrust on a section through the crown due to the weight of the structure alone is 7 tons 17 cwt. per square foot. When complete, rails were laid over the arch and a train of seven trucks, weighing 49 tons, with a wheel base of 57 feet, was run over the bridge. Ballast weighing 170 tons was then spread over the arch and the train again repeatedly run over the bridge. The maximum average thrust at the crown during the experiments reached the high value of 15 tons 2 cwt. per square foot. The arch showed no signs of failure or distress. The concrete consisted of gravel and Portland cement in the proportion of 6 to 1, and was laid in mass on close boarding set upon the centering.

Centrifugal Governor.—Sir W. Thomson has designed a centrifugal governor, in which the increase of centrifugal force due to increase of speed produces the regulating action without change of radius. The centrifugal force is made the normal pressure for a frictional arrangement simply and directly resisting the rotary motion. In an instrument exhibited at the Institute of Engineers in Scotland, the weight of the revolving masses and the power of the springs by which they are controlled was so adjusted as to require an increase of one foot-pound per second in the driving power for an increase of one per cent. in the speed above the desired amount.

Suez Canal.—Mr. Fowler, C.E., has recently published in the *Times* a careful report on the present condition and prospects of the Suez Canal, which is very favourable as to its success from an engineering point of view

whatever may be its commercial fortune. In regard to various points about which doubt has been expressed, he gives opinions founded on a careful examination of the data accumulated during the progress of the works. The Nile alluvium, which is already perceptibly altering the coast line at Port Said, penetrates the western breakwater in such quantities that he believes it will be better to render the breakwater solid than to keep the harbour clear by dredging. As to the filling up of the canal by desert sand, he states that, fortunately, only about 17 miles lying on either side of Lake Timsah are affected by drift sand to an extent requiring consideration. Into that portion of the canal 310,000 cubic yards drifted in twelve months, and in addition to the precautions taken by the company of planting trees and shrubs for some distance on either side of the canal, he is of opinion that powerful dredges will have to be maintained at this part of the canal, to keep the passage clear. To protect the banks from the wave of passing vessels he recommends protecting them throughout by stone pitching. From the Bitter lakes, exposing an area of 100,000 acres, the daily evaporation in summer will amount to the enormous quantity of 250,000,000 cubic feet, and this waste will have to be made up almost entirely from the Red Sea. Currents will thus be created in the Chalouf excavation, probably reaching, if not exceeding, in velocity two miles an hour. These currents will not be sufficient to injure the canal if properly protected, but may retard or assist navigation. Screw steamers are to be allowed to navigate the canal with their own power, and other vessels are to be taken through by steam tugs. Mr. Fowler thinks the commercial success of the enterprise will largely depend on the willingness of traders to construct sailing vessels with sufficient auxiliary steam-power to take them through the canal and down the Red Sea, and by their means to divert the large traffic now carried round the Cape.

Steam Carriage.—Mr. Fairlie and Mr. Samuels are working together in the production of a steam-carriage, or combined carriage and engine, for working the traffic on light railways laid on ordinary roads and branch lines. The carriage and engine are combined on a single frame, carried by two four-wheel bogies, and the wheels of the front bogie are coupled and driven by a pair of 8-inch steam cylinders supplied with steam by a "Field" boiler. The entire structure with 80 passengers weighs 20 tons, half of which is utilised as adhesion weight. The ratio of unpaying to paying load is only 2½ to 1, and the adhesion is sufficient to enable the carriage to ascend a gradient of 1 in 16 if sufficient steam-power were provided. With the cylinders proposed it would surmount gradients of 1 in 35 or 1 in 40.

Armour Plate.—An immense armour plate, 12 feet 8 inches long by 8 feet 6 inches wide and 5 inches thick, was recently rolled at the works of Sir John Brown & Co. on a new plan. In the manufacture of large plates it has hitherto been a great difficulty to heat piles of the necessary width. The plan adopted for the above plate was to heat a comparatively narrow pile; to roll it first in the direction of the width until sufficient breadth was attained; lastly to turn it and roll it lengthways. It is expected that by this plan plates 8 feet wide and 20 to 30 feet long will be obtained.

Injector Condenser.—Very great interest has been excited by an invention claimed by Mr. Morton and by Mr. Barclay, which, if it prove as successful

in practice as it has done in experiments, will introduce a fundamental change in the construction of the condensing engine. Hitherto the condensation of the exhaust steam has almost always been effected in the large separate condenser introduced by Watt, the condensation-water being pumped out by a large so-called air-pump. In a few instances surface condensation is employed, but the bulk of the condensing apparatus is then even larger than with Watt's condenser. Mr. Morton and Mr. Barclay have succeeded in dispensing with the separate condenser and air-pump, by a beautiful application of the principle of Giffard's injector, at the same time reducing the bulk of the condensing apparatus to very small dimensions. In Giffard's injector there are two concentric nozzles, one communicating with a boiler containing steam under pressure, the other with a tank of feed-water. The steam rushing through the steam nozzle condenses on the jet of water and communicates its vis viva to the water, thus driving it forwards into the boiler. In the injector condenser the exhaust steam at the moment of condensation similarly communicates its vis viva to the water jet and discharges it, against the atmospheric pressure, without the need of employing an air-pump. A paper on this condenser was read by Professor Rankine before the Scottish Institution of Engineers, which will be found in *Engineering* of December 25. The chief results of Professor Rankine's experiments are given in the following abstract:—

Power saved by dispensing with air-pump . .	1·0 Ind. H. P.
Power of engines	23·8 „ „
Mean back pressure in cylinders	4·0 lbs. per sq. in.
Mean vacuum in cylinders	10·7 „ „
Temperature of cold water	47° F.
Temperature of waste water	83½° F.

Graphic determination of Stress.—Mr. J. H. Cotterill, M.A., has described in *Engineering* of January 7, the beautiful graphic methods of obtaining the bending moments and stresses on transversely-loaded structures, introduced by Professor Culman of the Zürich Polytechnic School.

MEDICAL SCIENCE.

Action of Alkaline Sulphates when injected into the Veins.—The experiments which have been recorded by MM. Jolyet and Cahours in the *Archive de Physiologie* for February are of much importance, and show how much yet remains to be learned concerning the physiological action of even mineral substances. These chemists introduced into the veins on various occasions sulphates of soda, potash, and magnesia, and they believe they are justified in drawing these conclusions:—1. That the injection into the veins of neutral salts (sulphates of sodium or magnesium) produces no purgation, although these salts are active purgatives when introduced into the intestines. 2. These injections, by their poisonous results, enable us to distinguish between the sulphates of the three salts. In reference to this latter point, the authors state that similar experiments have been tried before by M. Grandeau, who

investigated the action of the salts of sodium, potassium, and rubidium; and who showed (1) that sodium salts may be introduced into the blood in very large doses without producing serious results; (2) that the salts of potassium similarly introduced are extremely poisonous, and have an immediate toxic effect, even in small doses. M. Bernard's experiments show that the potassium salts exert their action on the muscular tissue, and that death caused by injection of them into the blood is the result of cessation of heart action, due to arrest of the respiratory movements. MM. Jolyet and Cahours record numerous experiments on dogs, which show conclusively that the potassium salt has a very seriously poisonous influence on the heart, causing an immense increase in its actions. Similar experiments with sulphate of sodium prove (1) that this salt has no purgative effect in this way; and (2) that by diminishing the coagulability and plasticity of the blood, it promotes hæmorrhages, and retards cicatrization.

Temperature of the Body in Health.—Dr. Sydney Ringer gives an abstract of a paper lately laid before the Royal Society on this subject. He gives the results of the experiments made by himself and the late A. P. Stewart. The following are the conclusions. The average maximum temperature of the day in persons under 25 years of age is 99°·1 Fahr.; of those over 40, 98°·8 Fahr. There occurs a diurnal variation of the temperature, the highest point of which is maintained between the hours of 9 A.M. and 6 P.M. At about the last-named hour the temperature slowly and continuously falls, till, between 11 P.M. and 1 A.M., the maximum depression is reached. At about 3 A.M. it again rises, and reaches very nearly its highest point by 9 A.M. The diurnal variation in persons under 25 amounts, on an average, to 2°·2 Fahr.; but in persons between 40 and 50 it is very small, the average being not greater than 0°·87 Fahr.; nay, on some days no variation whatever happens. In these elderly people the temperature still further differs from that of young persons; for in the former the diurnal fall occurs at any hour, and not, as is the case with young persons, during the hours of night. Concerning the influence of food on the temperature of the body, the authors have concluded that none of the diurnal variations are in any way caused by the food we eat. The experiments to prove this conclusion are very numerous. Some were made with the breakfast, others with the dinner and tea; but all point to the conclusion just stated. This important question is very fully discussed in the section devoted to it. By cold baths both the surface of the body and the deep parts were lowered in temperature. The temperature of the surface was in some instances reduced to 88° Fahr.; but the heat so soon returned to all parts as to show that the cold bath is of very little use as a refrigerator of the body. The cold bath produced no alteration in the time or amount of the diurnal variation. This began at the same hour, and reached the same amount as on those days when no bath was taken. By hot-water or vapour baths the heat of the body could be raised very considerably. Thus, on some occasions, when using the general hot bath, the temperature under the tongue was noted to be between 103° and 104° Fahr.—a fever temperature. The body being heated considerably above the point at which combustion could maintain it, t was then shown with what rapidity heat may be lost, simply by radiation

and evaporation. The experiments tend to prove that hot baths in no way affect the diurnal variation of the temperature.

Influence of Medicaments on the Heart.—The *Proceedings of the French Society for Therapeutics* contains a paper on this point by M. Bordier, who recommends that in all therapeutical experiments the sphygmograph should be employed. By the use of this instrument, M. Bordier has been able readily to distinguish between drugs which increase and those which diminish the tension of the vessels.

Leptandra and Leptandrin.—*The Practitioner* for March gives an account of some experiments on these substances recently made by two American physicians, Dr. Adolphus and Dutcher. Leptandra is the name of a plant belonging to the *Scrophularceæ*. Adolphus recommends it as a cholagogue in doses of two grains of the root, or five drops of Merril's tincture. He says it acts at the same time as a tonic, so that it is possible and even advantageous to administer this remedy even in typhus and typhoid with much diarrhœa (! !), as it increases the digestive power, and also the appetite. He says that in desperate cases of typhoid, with extreme collapse, and colliquative diarrhœa, he has seen twenty doses of two or three drops of the tincture produce marvellous results, and he attributes the action to a specific influence on the portal circulation. He also recommends, in the early stages of the fever, leptandrin one grain, and bicarb. sodæ two grains every hour. Leptandrin must be given in doses of seven or eight grains to act as a pure *drastic*. In small and medium doses it acts on the liver and pancreas. He treats dysentery and cholera infantum with tincture of leptandra and glycerine, and explain its good effects by its supposed stimulant action upon the digestive secretions of the small intestines, which increases the powers of nutrition. Ammonia in combination with leptandra relieves the nervous symptoms in infantile choleraic diarrhœa. The addition of leptandra to quinine in intermittent and remittent fevers, according to Adolphus, greatly increases the efficiency of the latter. He also reports that enlargements of the abdominal viscera are greatly reduced by the use of an infusion of leptandra and gentian. In obstinate constipation of children, one-eighth grain doses of leptandrin are recommended; and the same drug proves useful to habitually constipated adults who become affected with bilious remittent. Dr. Dutcher by no means confirms the general conclusions of Adolphus.

Aggregation of Blood-corpuscles in the Vessels in Fever.—Dr. C. H. Bastian, of University College, has published some interesting observations on this point. He found, in a case of erysipelas of the scalp accompanied by delirium during life, that the small arteries and capillaries throughout the grey matter of the brain were more or less occluded by aggregated masses of white blood-corpuscles. The same capillary embolisms were met with in the kidneys and liver, leading to commencing degenerations of these organs. From observations which Dr. Bastian had previously made on the microscopical characters of the blood in cases of febrile disease associated with high temperature, he was led to believe that the white corpuscles, which seemed to show an increased irritability in these affections, might cohere so as to form masses capable of occluding small vessels. He is disposed to attribute the delirium occurring in this and in some other similar

febrile affections to these obliterations of vessels in the grey matter of the brain; and he is also disposed to think that the albuminuria so frequently met with in these affections may be explained by a similar affection in the kidney. These observations, says the *British Medical Journal*, open up an extensive field of further pathological research and clinical deduction.

The Contractions of the Heart.—In a lecture delivered at the Royal Institution on February 11, which formed part of his course on the "Involuntary Movements of Animals," Dr. Michael Foster exhibited the heart of a recently killed tortoise, which heart was placed in a platinum dish, where it continued to expand and contract with great steadiness. A long lever arm of straw had its shorter end fixed in contact with the heart, so that the other end of the lever moved up and down two inches with each motion of the organism, thus making the motions visible to the whole audience. The motion of the heart of another recently killed tortoise was made visible in the same way, though in the latter case the heart was not removed from the body. The lecturer said that he could not exhibit the heart of a warm-blooded animal in this way, because in such animals it ceases to beat within a few minutes instead of hours after the death of the brain, in consequence of the rapid way in which such hearts consume their nutrition. Cold-blooded animals like frogs have plenty of capital in the shape of nutrition inside their bodies, and can go without food for a long time. When the heart of a frog is cut into two or more pieces each part continues to beat, except the lowest point of the heart, which exhibits no motion when it is cut off. The nerves entering the great muscle, called the heart, have cells attached to them after their entrance, and to these nerve cells, which are found in all parts of the heart except the lower point, the observed motions seem to be in some way due.

Skin Tissue affected in Small-pox.—Herr Erismann has explored this pathological region, and has laid his results before the Academy of Vienna. He believes that the first trace of the disease is seen in the upper layer of the derma, and in the Malpighian layer of the epidermis; the blood-vessels of the papillæ of the derma exude liquid matter, which forms cells that penetrate into the Malpighian layer, and form the true small-pox pustule. The capillary follicle is only secondarily affected, and the capillary papilla hardly ever is involved in the destruction of parts. In hæmorrhagic variola the affection commences in the corium around the capillary follicle, and penetrates into the papilla, whose vessels are crowded with exudative corpuscles. He has found no traces of cryptogamic vegetation in any of the morbid specimens, which he placed in chromic acid for examination.

Influence of Pneumogastric Nerves on Respiration.—A paper by Herr Voit and Rauber appears in the report of the Academy of Sciences of Munich. It has been concluded from previous experiments of other physiologists that the amount of carbonic acid exhaled after section of the nerve is the same as that before. Herr Voit and Dr. Rauber find now that this is true only for the first few hours after the operation. At a later period, when the issue of the lung has begun to undergo a change, the quantity of carbonic acid diminishes rapidly, and that of oxygen is increased.

Sulphurous Acid in the Atmosphere.—Mr. Peter Spencer, in a paper on the presence of this acid in the air of Manchester, makes the following

observations. "Believing, as I do, that the evils of our town smoke are in a much larger degree due to the gases which result from our coal consumption than to the black smoke which is the one thing generally complained of and legislated against, it occurred to me that one of these gases, which has a most pernicious influence upon vegetation, and which can hardly be favourable as a constant breathing medium to animal life, could be made visible in its effects to the eye. This is sulphurous acid gas, a very considerable product of the combustion of coal, containing 2 per cent. sulphur on an average. The experiments I have made have been repeated some 15 to 20 times, and in two localities; the results are evident, and they show that the substance is present in the air to a considerable extent."—*Scientific Opinion*, March 10.

Morphia as an Antidote to Atropia.—The following case, reported in the *Allg. Med. Cent. Zeit.* No. 80, has been going through the provincial papers, and is no doubt reliable. A strong little boy, aged three and a half years, drank more than the half of a solution of a grain of atropia in three drachms of distilled water. He immediately succumbed to the poisonous influence. An eighth of a grain of morphia was injected under the skin of the foot. In ten minutes the beneficial effects of the morphia began to be manifested, and in a few hours the patient was out of danger. The pupil remained dilated for some days.

Influence of Common Salt in assisting the Absorption of certain Substances.—*L'Institut* for March contains an account of a paper read before the Academy of Sciences of St. Petersburg, by MM. Zabeline and Wassilewski, "On the Influence of Chloride of Sodium on the Absorption of Tribasic Phosphate of Lime and Metallic Iron." The authors had conducted their experiments on dogs. The facts seem to justify these two conclusions:—1. Phosphate of lime when introduced into the stomach with caseine is found to be absorbed in greatest quantity when the food contains much chloride of sodium. 2. Chloride of potassium, while it helps the organism to absorb iron more quickly than chloride of sodium, also assists in removing this metal through the secretions more rapidly than the former.

The Pathological Development of Lichen.—*Scientific Opinion*, March 17, in a report of a recent meeting of the Vienna Academy of Sciences, states that Herr Dr. Kohn described some of his microscopic observations on the lichen of scrofulous subjects. This morbid alteration of the skin attacks only young patients, and manifests itself in numerous flat nodules, arranged in groups, and as a rule more frequent on the trunk than other parts. These nodules last for several months, and when they disappear, they leave a cicatrix and an accumulation of pigmentary matter. The essential pathological character of this morbid condition is the existence of an exudation of cells within and around the hair follicles and the accompanying sebaceous glands. In the first stages these cells may be seen lying in the vessels, then they make their way to the base of the sebaceous glands, and ultimately they gain the interior of the follicle, and completely fill it, expelling the normal secreting cells.

Errors of Architects as to Ventilation.—Dr. Edward Smith, who read a very lengthy and interesting paper on ventilation before the Society of Arts (February 24), states that architects in regard to this point fall into error: 1. In not duly estimating the practical limits of the law that heated air

ascends, and the relation of numbers of inmates and size of rooms in the application of the law. 2. In not duly considering that air-shafts, acting under that law, cannot act in all seasons, and with or without fire alike. 3. In not duly estimating the amount of air which can be admitted by windows and doors alone. 4. In not duly estimating the practical limits to which an entering current may be carried, whether from one or both sides of a room. 5. In not duly considering the effects of currents upon inmates, and the limitation thus demanded upon the amount, force, and elevation of currents. 6. In not duly estimating the inverse relation of ventilation to temperature in its effect upon inmates, and particularly upon the old and the young. 7. In not duly estimating the influence of the winds, and the impediments of surrounding buildings, &c., upon each aspect of a building. 8. In having incorrect views as to the direction of the current through ventilators at different elevations.

Medical Photographs.—A contemporary states that among other papers which have been forwarded to the French Academy of Sciences to compete for the Montyon prize of 1869, given for the encouragement of medicine and surgery, are a collection of photographic studies of the nervous system of man and several of the superior animals, taken from sections of congealed nervous tissue.

Medical Nomenclature.—The volume containing the future nomenclature of medicine has been issued by the Royal College of Physicians. We think it will have to undergo revision at some future time, for we cannot assent to the philosophical principles, or the ideas of precision involved in such a classification of stomach affections as the following: Pyrosis, hæmatemesis, gastric ulcer, vomiting and dyspepsia. Why has the convenient and now much employed term "gastric catarrh" been omitted? What is dyspepsia as distinguished from pyrosis? And what is vomiting as an individual disease of the stomach?

Snake Poison and its Cure.—Several cases have lately been recorded from Australia. It is said that Professor Halford treats snake bites successfully by injecting solution of ammonia into the veins! We suppose on the general principle that desperate cases demand desperate remedies.

Professor Huxley continues his course of lectures on the "Comparative Anatomy of Vertebrates," at the Royal College of Surgeons.

METALLURGY, MINERALOGY, AND MINING.

Assaying Silver-Compounds in the Wet Way.—M. Stas makes the following remarks on this point:—The mode of testing in the wet way in order to fix the standard of silver substances, as established by Gay-Lussac, is open, under certain conditions, to a source of error, arising from the solubility of chloride of silver in the very liquid to which its origin is due. This solution, whatever its mode of production may be, is precipitated equally by a decimal solution of silver and by chlorhydric acid. The extent to which this precipitation ensues is uncertain. At the ordinary temperature, there may be a variation of from one to six thousandths in 100 c.c. of the liquid. Prac-

tically, it is quite possible, while still preserving the simplicity of the wet method, as invented by Gay-Lussac, to substitute a bromide for a chloride in precipitating silver, and thus remove absolutely those anomalies which have been observed to be attendant upon the use of a chloride or of chlorhydric acid.—Vide *Chemical News*, Jan. 1.

The Characters of the Mineral Kotchoubeite.—The Duke de Leuchtenberg recently sent a paper to the Academy of Science of St. Petersburg in which he gives a comparative examination of the minerals *kotchoubeite*, *kammererite* and *pennine*. The author referred especially to the great importance of an optical examination of minerals, such as had been conducted in the researches of M. des Cloizeaux and others. In proof of this, he stated that M. Kokcharoff, while examining with a polariscope-microscope a mineral brought from the Oural by M. de Morny, and supposed to be kammerite, found that it presented two optic axes. On this fact he founded a new species, to which, in honour of M. Kotchoubey, he gave the name ot "Kotchoubeite." This mineral, he says, presents itself ordinarily under the form of pyramidal crystals. It is of a reddish violet, transparent in thin sections, and translucent in thick ones. It is flexible, but is hardly elastic. Its hardness is $=2$, its density is 2·679. Divided into thin plates and heated over the spirit-lamp, it becomes green without losing its transparency; it assumes a violet hue in cooling. In the blowpipe, or under a great heat, it loses its water, ceases to be transparent, and becomes of a yellow colour. It is attacked by acids, and especially so by sulphuric acid.—Vide *L'Institut*, March 10.

Molecular Phenomena in Iron.—In a paper read before the Royal Society in January, Mr. Gore, F.R.S., of Birmingham, described a novel phenomenon in connection with iron wire. The following abstract is given by the *Mechanics Magazine*:—A strained iron wire was heated to redness by a current of voltaic electricity, and then, the current being discontinued, was allowed to cool. It was observed that there arrived a moment in the process of cooling at which the wire suddenly elongated, and then gradually shortened, until it became perfectly cold, remaining, however, permanently elongated. No other metal besides iron exhibited this peculiarity, which Mr. Gore attributes to a momentary molecular change, and he points out that this change would probably happen in large masses of wrought iron and would come into operation in various cases where these matters are subjected to the conjoint influence of heat and strain, as in various engineering operations, the destruction of buildings by fire, and other cases. The phenomenon deserves a further investigation, since every fact relating to iron is of importance to us.

A Crystalline Modification of Silicic Acid.—In a paper presented to the Berlin Academy of Sciences, and subsequently published in Poggendorff's *Annalen*, Herr Ruth gave an account of the above. There are as yet, he said, only two forms of silica known with certainty to exist—one is the crystalline and the other is the amorphous. The crystalline silica is quartz whose specific gravity is 2·6; the amorphous form has a density which varies between 2·2 and 2·3. The amorphous silica appears in nature as opal and hyalite; such is also the silica dissolved by steam, and that found in organised bodies. Herr Jerzsch tried to prove that dense crystalline silica

is dimorphous and may also crystallise in the triclinic system, but this has not been universally admitted. The opinion that silica of low density is always amorphous is, said the author, erroneous: it exists in crystals. These crystals are colourless and limpid, with polished brilliant faces. Their measurement is difficult, because of their small size (hardly one millimètre). They are arranged in groups of twos and threes, and the latter being the most common, the term Tridymite has been given to this new mineral. Its system is the hexagonal, but very different from that of quartz. The fundamental form is the hexagonal dodecahedron. The hardness is equal, or nearly so, to that of quartz, and separate crystals are very rare. The specific gravity, taken at from 15° to 16° C., is from 2·326 and 2·312 to 2·295. Tridymite is infusible in the blowpipe, and its blowpipe reactions present no remarkable features. The analysis of the crystals (pounded in a steel mortar and fused with carbonate of soda) gave the following results in two cases:—

	1st	2nd
Silicic acid	96·1	95·5
Oxide of iron	1·9	1·7
Magnesia and alumina	1·3	1·2
Loss	0·66	0·66
	99·96	99·06

The iron, the author thinks, was derived from the mortar, and the other elements from the matrix in which the crystals presented themselves.

Alloys of Copper and Tin.—The Paris Correspondent of the *Chemical News* (whose letter, by the way, is always full of interesting details) states that in a note communicated to the Academy by M. Riche, the following facts concerning the alloys of copper and tin are given. The question of density is first taken. Some determinations were made upon bars of these metals, weighing from 50 to 60 grms., but the results obtained were unimportant, owing to the great difference which exists in these alloys. The same metals, reduced to fine powder, were afterwards operated upon, when it was observed that the contraction increases very regularly from the very rich alloy in tin to the mixture $SnCu_2$, and from this point it increases suddenly, arriving at a maximum, when the copper and tin are united in the relation of 1 to 3. The density diminishes from this point, then rises again nearly regularly; the density of the richest copper alloys is inferior to the mixture $SnCu_3$, which only contains 62 per cent. of copper. Besides, this alloy may be distinguished from all the others by its properties; it is brittle enough to be pounded in a mortar, and forms crystals of a bluish tint, not resembling in the least either copper or tin. M. Riche gives a number of formulæ, expressing the composition of the definite compounds which copper forms with tin and their properties. Referring to liquefaction, he then observes: "In order to separate these alloys, the mass should be moved about when becoming solid, to separate the crystals whilst forming." The fusibility of these alloys has been determined by the thermo-electric pyrometer. M. Riche has operated comparatively with these alloys, and with metals whose fusing points have been settled by various experimenters. Numerous determinations show that the solidification of the alloys $SnCu_3$ and $SnCu_4$ takes place at a temperature somewhere between the fusion point

of antimony and the boiling point of cadmium.—Vide *Chemical News*, March 5.

The Mode of Formation of Precious Stones.—One of the most interesting papers presented for some time to the Royal Society is that which appears in the number of the *Proceedings* just issued, and which was read on February 18 by Mr. H. C. Sorby. It deals with the natural structure of the different precious stones, and it leads to the following conclusion:—On the whole, the various facts seem to show that ruby, sapphire, spinel, and emerald were formed at a moderately high temperature, under so great a pressure that water might be present in a liquid state. The whole structure of diamond is so peculiar that it can scarcely be looked upon as positive evidence of a high temperature, though not at all opposed to that supposition. The absence of fluid-cavities containing water or a saline solution does not by any means prove that water was entirely absent, because the fact of its becoming enclosed in crystals depends so much on their nature. At the same time the occurrence of fluid-cavities containing what seems to be merely liquid carbonic acid, is scarcely reconcilable with the presence of more than a very little water in either a liquid or gaseous form. "We may here say that we do not agree with those authors who maintain that the curved or irregular form of the fluid-cavities is proof of the minerals having been in a soft state, since analogous facts are seen in the case of crystals deposited from solution."

METEOROLOGY.

The Mean Temperature of the Superficial Structure of the Earth has formed the subject of a communication to the French Academy by M. Becquerel. The paper contains too many details for a full abstract, but some of its conclusions are of interest. If, says the author, we take the mean of five years, which is the most rational method, we deduce the following inferences:—1. The mean temperature presents but slight variations from 6 to 21 mètres, and from 21 to 26 mètres. 2. From 1 to 36 mètres the difference has been from 1°·36. But if it is demonstrated that during the five years the mean temperatures have been sensibly the same from 6 to 21 mètres, it does not necessarily follow that the temperature at these various points has been stationary. To establish a rule in the matter, we must investigate the variations of temperature in the course of the year, according to the seasons; that is to say, the differences between the mean, annual, maxima, and minima. The variations decrease to 21 mètres, where they are *nil;* at 26 mètres the variation is half a degree; then up to 36 mètres there is no variation. Thus all the earth strata have a constant temperature at 21, 31, or 36 mètres. Where, then, shall we place the stratum of invariable temperature? Is it at 21, at 31, or at 36 mètres? Or might we not find it still lower, if we could extend our observations beyond this point?

A New Anemometer, which costs less than other forms and is both accurate and durable, has been described by Mr. W. Oxley at the meeting of the Manchester Literary and Scientific Society (February 2). The

anemometer itself is a circular box, 11 in. diameter and 2¼ in. deep, which moves freely on its centre on a pivot at the top of a rod fixed firmly into a foot plate, so as to prevent oscillation. The box is horizontal, provided with a space on one side, in which is placed a well-tempered steel spring, which gives a range of 2¾ in. from zero to what represents 40 lb. pressure on the square foot. To this spring is attached a brass rod, or rack, which works the pinion, on the axle of which are placed two fingers, one live and the other dead. These fingers move according to the pressure given (or movement of the pinion), and thus the force is shown by looking at the dial-plate; and the figure to which the live finger points shows the present force of the wind, whilst the dead finger is opposite the figure, showing the maximum pressure that the wind has attained during a given period. This is effected by a small pivot, or pin, at the point of the dead finger projecting *above* the live one, so that as the live finger is forced by the pressure it carries the other with it, and leaves it at that point if the wind decreases. In front of the spring, in the space already referred to, is a small disc attached to a rod, on which is placed a wind-plate of 6 in. square. This plate is kept to the wind by a vane on the opposite side of the circular box, and as its area is just one-fourth of a square foot, the graduated dial figures being multiplied by four, gives the same result as though the plate were a foot square. This size of plate gives lightness, and reduces the friction to a minimum. The working parts of the instrument are protected from the weather by a glass lid or cover.

MICROSCOPY.

The Monthly Microscopical Journal constitutes one of the most important features of the quarter in this department. A glance at it shows that the Fellows of the Royal Microscopical Society receive a much larger return for their subscription than they did under the *régime* of the old journal, which was published quarterly. For example: let us compare, what are strictly comparable, the January number of the *Quarterly Journal of Microscopical Science* and the numbers for January, February, and March, of the *Monthly Microscopical Journal*. The first contains some ten or eleven articles, all good in their way. The contents, merely in original contributions, of the three latter are as follows:—

January.—Structure of Papillæ and Termination of Nerves in Muscle of Common Frog's Tongue. By Dr. R. L. Maddox. With Plate.—Relation of Microscopic Fungi to Cholera. By Dr. J. L. W. Thudicum.—Heliostat for Photo-Micography. By Dr. R. L. Maddox. With Plate.—Heliostat for Photo-Micography. By Lieut.-Col. J. J. Woodward, M.D. U.S. Army Medical Department. With Plate.—A Modification of the Binocular Telescope. By M. Nachet. Illustrated.—The Vital Functions of the Deep Sea Protozoa. By Dr. G. C. Wallich.—The Formation of the Blastoderm in Crustacea. By MM. Van Beneden and Bessels.

February.—On the Classification and Arrangement of Microscopic Objects. By James Murie, M.D., F.L.S.—Immersion Objectives and Test Objects. By John Mayall, Jun., F.R.M.S.—Notes on Mounting Animal Tissues for Microscopical Examination. By H. Charlton Bastian, M.D., F.R.S.—Some Undescribed Rhizopods from the North Atlantic Deposits. By G. C. Wallich, M.D., F.L.S.—On the Construction of Object-Glasses. By F. H. Wenham.—The Organ of Hearing in Mollusks. By M. Lacaze-Duthiers.—On a New Infusorium. By J. G. Tatem, F.L.S.

March.—The Address of the President of the Royal Microscopical Society. —The Composite Structure of Simple Leaves. By John Gorham, M.R.C.S.—On the Construction of Object Glasses for the Microscope. By F. H. Wenham.—On a New Growing Slide. By C. J. Muller.—On Triarthra Longiseta. By C. T. Hudson, LL.D.—Professor Owen on Magnetic and Amœbal Phenomena. By Lionel S. Beale, M.B., F.R.S.

Had the Fellows of the Royal Microscopical Society continued the old journal, they would have been furnished during the quarter with about eleven articles, and 112 pages of letter-press. Under the new organisation they have received their reports *monthly*, they have been supplied with *twenty* original communications, and they have received exactly 196 pages of matter.

Preparing Sections of Teeth.—The following formula is given by Professor Cutler in the American *Dental Register*. Procure a fresh pulp, and at once split it open from end to end; then lay it on a slip of glass slightly coated with balsam pitch, and spread it out, after slightly rounding the glass (something like a hunter stretches his coon skin on a barrel to dry); then remove as much of the cell contents as convenient, by washing with a piece of sponge and acetic acid or ether, rubbing lengthwise with pulp. This will show more clearly the septum of filaments, and also show the countless openings through the pulp membrane, where the fibrils pass out into the dentine. These specimens will not keep well for permanent use, unless mounted in pitch on both sides; even then changes take place.

A Substitute for a Nose-piece is thus described by Mr. James Vogan, in *Science Gossip* for January, but we do not think it will be found very useful, viz.: Divide the circumference of the screw, both of the "object-glass" and "body," into four equal parts; then file away all the thread in two opposite quarters, leaving the remaining two opposite quarters intact. It is better in practice to remove slightly more than one-fourth on each side, so as to allow free clearance. The object-glass may now, by placing it so that the remaining portions of thread come opposite the corresponding gaps, be passed into the body, right up to the shoulder, *without turning it round at all;* and about one-eighth of a turn fixes it in its place as firmly as if screwed in. The adoption of this plan does not prevent the use of the altered object-glasses with other instruments, nor does it preclude the use of unaltered object-glasses with altered bodies.

How to Count the Lines in Nobert's Plates.—The following method is given in a late number of *Silliman's Journal of Science.* "If a cobweb micrometer is used, the micrometer eye-piece should be firmly clamped in a stand screwed to the table, so that the eye-piece is close to the end of the microscope-tube, but does not touch it—a piece of black velvet being used to

complete the connection. The motion of the micrometer-screw now communicates no tremor to the microscope, and all difficulty in counting the lines seen (whether real or spurious) disappears." Still better than this is the following method:—The microscope being set up in a dark room, as though to take a photograph, and the eye-piece being removed, the image of the band to be counted is received on a piece of plate-glass in the plate-holder, and viewed with a focussing-glass, on the field-lens of which a black point is marked; as the focussing-glass is moved on the plate from side to side, the black point is moved from line to line. The lines may thus be counted with as much ease and precision as though they were large enough to be touched with the finger.—*Monthly Microscopical Journal*, February.

How to Construct Object-Glasses.—Those who wish to know not only the scientific principles on which the best object-glasses are made, but the most satisfactory methods of manufacture, should read the excellent papers of Mr. F. H. Wenham which are now appearing in the *Monthly Microscopical Journal.*

The Quekett Club Soirée was held at University College on the evening of March 12. It was an immense success. More than 1,500 persons were present, and the 200 microscopes on the table were provided with objects of more than usual interest.

A new Growing Slide, which is simple and convenient, is described by Mr. C. J. Muller in the *Monthly Microscopical Journal* of March. Any ordinary glass-slide is pierced with a minute hole, at about three-tenths of an inch from the centre on one side. When an object under investigation is put upon it immersed in water, the thin glass cover is so placed as to include this hole, which may be near the margin of the disc. When it is desired to keep the specimen moist while off the stage of the microscope, the slide is placed in the undermentioned piece of apparatus; viz., a flat trough 7 inches long, 2½ inches wide, with straight sides ¾ of an inch high. In this the slide is placed, object uppermost, with one end (that nearest the hole) resting against the bottom of the vessel on one side, and the other end resting upon the edge of it. Sufficient water is put into the vessel to admit of the liquid reaching within a quarter or half an inch of the glass cover on the uppermost side, when it will be found that, by capillary attraction, the water on the under-side reaches beyond the centre of the slide, and consequently beyond the hole with which it is pierced. In this state the object will remain moist so long as the trough contains a sufficient quantity of water. When required to be placed on the stage of the microscope, the water is easily wiped off without disturbing the object.

Obtaining Diatoms from Guano.—In a paper which he read before the Natural History Society of Armagh on January 17, Dr. Lewis B. Mills said that in the guano usually to be had in this country the diatoms form a very small percentage of the entire mass, and to prepare the deposit for mounting in the rough, according to the usual process, would generally give very poor results, and discourage all except those well skilled in manipulation. However, the most unproductive samples of guano contain some diatoms, and fair slides may be prepared from the material, if the process of selection be adopted in their preparation. For this process, it is not needful to use more

nitric acid in the previous cleaning than that which may be necessary to clean the diatoms themselves; and the use of sulphuric acid and chlorate of potash is not required, as the bleaching of the unsightly foreign material would be useless. A large drop of the prepared material must be spread near the edge of a glass slide: the appearance of this under a simple microscope with a glass of one-inch focus will be that of much dirty material containing a few clean diatoms; the best of these latter may be pushed out of the water by means of a needle, and nicely arranged near the centre of the slide. The slide may now be raised, and the water may be carefully wiped off; the turning of the slide on its edge, or the wiping away of the water, will not disturb the diatoms selected and placed, as they remain attached to the glass sufficiently firmly to admit of the movements required. In this way the choice diatoms may be selected out of many drops, and be perfectly free from an unsightly speck of the half-cleaned foreign material.

PHOTOGRAPHY.

New Photocrayon Process.—Mr. Sarony, photographer to the Queen, Scarborough, has recently introduced what he designates photocrayon portraits. They have furnished material for discussions at the London photographic societies and in the journals devoted to the art. The position of Mr. Sarony as the principal of one of the largest photographic establishments in the kingdom, and as an artist of skill and taste, has secured for his new crayon photographs the favourable attention of his brethren. The portrait is executed on a glass plate fourteen inches in size, and is an enlarged vignette from an ordinary carte negative. The method by which they are produced is simple in the extreme. The negative is inserted, as a slide, into a magic lantern, and the enlarged image is thrown upon a sheet of glass previously made sensitive by being collodionised and excited in a 40-grain nitrate of silver bath. When magnesium ribbon is employed as the source of illumination, an exposure of half-a-minute suffices to impress an image, which, after development with a solution of pyrogallic acid one grain, and citric acid one and a-half grain in each ounce of water, is fixed with hyposulphite of soda, washed, and varnished. In this state it is a transparence, the whites of the picture being represented by clear glass, and the shadows by a dark deposit of silver more or less intense. It is now backed by a piece of drawing paper of any desired tint, on which hatchings by a crayon have been made so as to surround and, where necessary, merge into the figure. The effect of the whole is that of a photograph on drawing paper, skilfully finished in crayon or chalk, the hatchings by which the vignetted subject merges into the ground of the picture conferring what is termed an "artistic" appearance, and conveying the belief that the picture has been elaborately worked upon by the artist; whereas the hatchings on the backing papers are printed by lithography. It is a mechanical method of producing art imitations of wrought-up photographic enlargements which will probably be much adopted. The rough texture of the backing

proper confers a peculiar and good effect, and even skilled artists have been deceived by these bold imitations of elaborate work.

Printing Photographs by Mechanical Means.—The expense, loss of time, and other disadvantages attendant upon the usual method of printing photographs by the agency of silver salts have for several years back acted as an incentive to have them printed by mechanical means, so as to provide, among other things, for the wants of book illustration. Within the past few weeks a process of printing photographs by means of fatty ink, discovered by Albert of Munich, has been much spoken of. The complete details of the process have not yet been published, but as far as it is known it has a strong resemblance to the photo-lithographic process of M. Tessie du Motay. A very thick plate of glass is first coated with a layer composed of albumen, gelatine, and bichromate of potash, which is then rendered insoluble by exposure to the light. On the surface is poured a similar sensitive layer of gelatine and bichromate of potash dissolved in water. When dry, the plate is exposed to light under a negative, after which it is washed and treated as a lithographic stone; for a surface so treated possesses the property of absorbing water, and consequently resisting the application of fatty ink in the inverse ratio of the action of light, or in proportion as the light passing through the negative has not acted upon the sensitive layer. The photographs thus printed are said to be very fine, and nearly a thousand can be obtained from one plate.

Plain Paper Prints.—Many photographers are now employing plain as well as albumenised paper. Although for several years the latter has been almost exclusively used, there now appears to be a disposition to test the capabilities of plain paper more thoroughly than has previously been done. M. de Constant produces fine, delicate, and yet vigorous pictures by employing a stout paper sized with arrowroot, sensitising in a neutral silver bath of eight per cent., and, when dry, exposing it for ten or fifteen minutes to the vapour of ammonia. It is then printed, toned, and fixed in the usual manner; only the gold-toning bath must be alkaline, and weaker than that commonly employed for albumenised paper. When washed and dried, the prints are treated with a warm solution of gelatine, and are afterwards finished by the application of weak negative varnish.

New Lime Light.—A lime light of a simple yet effective nature has recently been introduced, and, from the purity and actinic power of the light, it is expected that it will prove of great use to photographers. It is the ordinary oxyhydrogen or lime light, with a slight difference, however, but one which, in its results, may be fraught with importance, being nothing less than a substitution of common atmospheric air for the pure oxygen hitherto employed. A stream of air is caused to pass through a gas flame issuing from a suitable burner, and to impinge upon the lime as in the ordinary oxyhydrogen light, but the lime is so arranged as to present a number of jagged edges to the blowpipe flame, in preference to the smooth surface of the common lime cylinder. Lime of a soft quality appears to answer better than hard lime; and magnesia, mixed with lime and asbestos, has also been employed with advantage. The cost of the light is thus reduced to that of the common gas used, and as from a given volume of common gas a more intense light can be obtained in this manner than by the ordi-

nary method of combustion, the economy of this light, when employed for domestic and other ordinary lighting purposes, is a subject which merits attention. The Messrs. Darker, of Lambeth, who have introduced this light, are engaged in the construction of burners to suit the various requirements of photographers.

Another new Dry Process.—Dr. George Kemp, who is well known as a careful experimentalist in photographic science, as well as a clear writer on the subject, has communicated to the pages of the *British Journal of Photography* the details of a dry process which has engaged much of his attention and which has yielded him highly successful results. The most efficient preservations for dry plates, according to Dr. Kemp, are those that contain nitrogen. In some of these this element presents itself in such wise that the aggregate body may be assumed to exist as a compound of nitrogen and hydrogen combined with a complementary organic group, from which the ammonia has, in a theoretical point of view, been eliminated. In most of the cases, the ammonia can be liberated by familiar chemical devices, and a considerable number of such bodies usually designated vegetable bases were examined in relation to their conduct as connected with actinic reactions. From the experiments made, Dr. Kemp has deduced the law that all bodies which contain ammonia in the condition alluded to are more or less efficient when applied as preservative agents. From this theory he has worked out the following process:—On an ounce of distilled water place twenty grains of fresh powdered cocoa nib; mix and allow to digest for an hour, no heat being employed. Filter this fluid and add two drops each of glycerine and glacial acetic acid. The plate, being collodionised and excited as in other processes, must be thoroughly washed, after which the preservative solution is applied and made to permeate all the film; after which it is again submitted to a thorough washing, and when dried by a strong heat is ready for storing or for immediate exposure. The sensitiveness is nearly, if not quite, as great as that of wet plates. The picture is developed by a two-grain solution of pyrogallic acid containing acetic acid and nitrate of silver.

Danger of using India-Rubber.—Mr. Samuel Fry, in *Photographic News*, warns photographers against employing india-rubber either as a substratum for the negative collodion film, for which it has been much used in certain dry processes, or as a varnish for protecting the finished negative. It is, he says, a very destructible gum. Under changes of temperature or hygrometric variation it loses its elasticity, becomes first brittle, and is ultimately reduced to a brown powder, having neither coherence nor any of the properties of the original substance. In consequence of this instability, many negatives have been destroyed.

Cracking of Negative Films.—Mr. Matthew Whiting having had some negatives which presented a honeycombed appearance within a few months after they were taken, has restored to them their original homogeneity of surface by pouring over them a little warm alcohol, which softened the varnish and caused the film to lie flat.

The Truth of Photography versus *Artistic Licence.*—Mr. R. H. Bow, C.E., of Edinburgh, has recently been applying the theodolite to ascertain in a scientific manner the truth of art as displayed in certain well-known pictures by artists of reputation. The result of this crucial test is

that artists are found to have been taking liberties with nature. The declivities in the mountains of Samuel Bough's "Loch Lomond," a picture that has been engraved and published during the past year by the Association for the Promotion of the Fine Arts in Scotland, are shown by Mr. Bow's scientific test to be exaggerated to the extent of fifty per cent. Similarly, comparing the famous picture by Mr. Waller Paton, "Edinburgh from the Echoing Rocks," with a photograph taken from the same spot and verified by the theodolite, he finds that the true slope of the notable *débris* of Salisbury Crags forms an angle of thirty-eight and a-half degrees with the horizon, while the artist (one of the highest standing), has made it to be not less than fifty degrees. In like manner science makes the moon to subtend a certain angle; artistic licence makes it to be seven and a-half times larger than it really is. *Apropos* of this, in a recent political parody of "The Fighting Temeraire," in which both sun and moon are visible, the artist had apparently considered scientific accuracy so little a matter of moment that he had actually turned the crescented moon, in its relation to the sun, back side foremost.

Photographs of Authors.—A bookseller in Paris has just started a novel idea, that of placing a photograph of the author on every book which he places in his window. He has evidently studied human nature to some purpose.

PHYSICS.

Cohesion-figures.—In a recent communication on these extremely interesting physical phenomena, Mr. Charles Tomlinson gives an account of the substances which may be employed to exhibit cohesion-figures. Solid carbolic acid, in small fragments, rotates on the water surface with immense velocity, after the manner of camphor. (Camphor also may be tried, but the fragments should be scraped from a freshly-cut surface with the point of a pen-knife.) If a needle of the commercial acid be placed on the water, it darts about suddenly, liquefies, forms into a disc, from which angry-looking waving forked tongues proceed, and so it wastes away. If the liquid acid be used, care must be taken to deliver it gently to the surface, or it will slip through and form an inert globule at the bottom of the water. Carbolic acid, or a mixture of this and cresylic acid, forms an active vigorous figure, and if a drop be placed on the same surface with what is left of the lavender figure, the mutual attractions and repulsions form a surprising sight. Cresylic acid leaves delicate silvery flakes on the surface of the water, and in this way the presence of a few drops per cent. of this acid in carbolic acid can be detected.—Vide *Chemical News*, No. 447.

Telescopic Photography.—The *Photographic News* states that M. Schroder, of Hamburg, is at present occupied in constructing a telescope to be fitted with clock-work, for photographing the heavenly bodies. The instrument is so arranged that the object to be reproduced will be considerably enlarged before it is thrown upon the sensitised plate.

A Method of Viewing the Solar Prominences.—At a meeting of the Royal Society, in February, Mr. W. Huggins stated that, on the 13th of that

month, he had succeeded in distinguishing the form of a solar prominence. A spectroscope was used; a narrow slit was inserted after the train of prisms before the object-glass of the little telescope. This slit limited the light entering the telescope to that of the refrangibility of the bright line coincident with C. The slit of the spectroscope was then widened sufficiently to admit the form of the prominence to be seen. The spectrum then became so impure that the prominence could not then be discerned. A great part of the light of refrangibilities removed far from that of C was then absorbed by a piece of deep ruby glass. The prominence was then distinctly perceived.

Metals in the Galvanic Current.—The *Chemical News* (January 1) describes the following experiment, which has recently been made by Herr Wöhler, and which is supplementary to others of a similar kind:—Palladium as positive electrode of two Bunsen's cells, immersed in acidulated (sulph. acid) water, becomes gradually covered with an almost black film of peroxide (PdO_2). Upon lead and thalium brown peroxide and black oxide are deposited. Osmium, in the ordinary porous condition, is freely converted into osmic acid (OsO_4). If, as electrolyte, a dilute solution of sodium hydrate is employed, the solution assumes a deep yellow colour, while on the negative electrode metal is deposited. The same is the case with ruthenium. Osm-iridium, in its natural state, readily dissolves in the alkaline electrolyte.

How to Take Oleographs.—Dr. R. C. Moffat has given the following account of a method of producing these interesting results:—The oil patterns uninjured can as readily be transferred from the surface of the water, and permanently fixed to be placed in our albums, as we can pour water from one vessel to another. No matter what colours we desire, we can obtain them of any hue we please. They rival the most beautiful photographs. The faintest tracery is brought out with the most perfect fidelity. Two well-known photographers, to whom they were shown, declared they were excellent photographs, and yet not a trace of the chemicals photographers use was employed. The process can be described in three lines:—Obtain the oil pattern, note the time, lay a piece of glazed surface paper on the pattern for an instant, take it off, place on the surface of a plate of ink for a moment, remove and wash off the excess of ink with water, and your pattern is there as it was on the water. You now have an exquisite representation in black, as fine as any photograph. A scarlet is obtained by employing a solution of cochineal or any of the scarlet coal-tar colours. We have them in orange, red, scarlet, black, blue, and other tints. A good result is got by first passing the paper containing the pattern of oil through ink and then through cochineal. The principle of the matter is this. The paper absorbs the oil at several parts to the exclusion of the water. The ink colours the water parts, but at the same time tints the oil parts very faintly, which gives it the appearance of relievo. Any kind of paper almost will do. Tissue, green, glazed, white, &c. give pretty good results.

Glass for Lenses.—It is stated that glass having a density of 4·4 is now manufactured by Messrs. Chance, the great Birmingham firm.

Use of Telegraphy in Ascertaining Longitude.—M. Quetelet has recently laid before the Belgian Academy of Sciences an account of the observations

made in August and September last to determine the differences in longitude between the observations of Leyden and Brussels. These inquiries had been made at the request of M. Kaiser, of the University of Leyden and the director of the Leyden Observatory. The method used was that of telegraphic signals. The two observatories determined to make simultaneous observations of the same bodies, and to signal the results to each other. Relative to this mode of determination, M. Quetelet states that in 1853 the galvanic method was employed to determine the longitude of Brussels in relation to the Royal Observatory of Greenwich. It was the first time, he said, that this mode—of American origin—was employed on so large a scale. The enterprise succeeded, and Mr. Airy made it the subject of a memoir which appeared in vol. xxiv. of the *Proceedings of the Astronomical Society of London*, under the title "On the Difference of Longitude between the Observatories of Brussels and Greenwich, as determined by Galvanic Signals," a translation of which memoir appears in the *Annales de l'Observatoire Royal de Bruxelles*.

How to ascertain the Heat of the Stars.—Mr. Huggins a few weeks since published his description of an ingenious contrivance for this purpose. He thus described how the observation of temperature was taken:—The apparatus was fixed to the telescope so that the surface of the thermopile would be at the focal point of the object-glass. The apparatus was allowed to remain attached to the telescope for hours, or sometimes for days, the wires being in connection with the galvanometer until the heat had become uniformly distributed within the apparatus containing the pile, and the needle remained at zero, or was steadily deflected to the extent of a degree or two from zero. When observations were to be made the shutter of the dome was opened, and the telescope, by means of the finder, was directed to a part of the sky near the star to be examined where there were no bright stars. In this state of things the needle was watched, and if in four or five minutes no deviation of the needle had taken place, then by means of the finder the telescope was moved the small distance necessary to bring the image of the star exactly upon the face of the pile, which could be ascertained by the position of the star as seen in the finder. The image of the star was kept upon the small pile by means of the clock-motion attached to the telescope. The needle was then watched during five minutes or longer; almost always the needle began to move as soon as the image of the star fell upon it. The telescope was then moved, so as to direct it again to the sky near the star. Generally in one or two minutes the needle began to return towards its original position.

The Constitution of Clouds.—Dr. Tyndall's recent investigations on this subject are of the highest interest to physicists. Speaking of toluol, he says:—"Every cloud-particle has consumed a polyhedron of vapour in its formation, and it is manifest that the size of the particle must depend, not only on the size of the vapour polyhedron, but also on the relation of the density of the vapour to that of its liquid. If the vapour were light and the liquid heavy, other things being equal, the cloud-particle would be smaller than if the vapour were heavy and the liquid light. There would evidently be more shrinkage in the one case than in the other. These considerations were found valid throughout the experiments. The case of toluol

may be taken as representative of a great number of others. The specific gravity of this liquid is 0°·85, that of water being unity; the specific gravity of its vapour is 3°·26, that of aqueous vapour being 0°·6. Now, as the size of the cloud-particle is directly proportional to the specific gravity of the vapour, and inversely proportional to the specific gravity of the liquid, an easy calculation proves that, assuming the size of the vapour polyhedra in both cases to be the same, the size of the particle of toluol cloud must be more than six times that of the particle of aqueous cloud. It is probably impossible to test this question with numerical accuracy; but the comparative coarseness of the toluol cloud is strikingly manifest to the naked eye. The case is representative. In fact, aqueous vapour is without a parallel in these particulars; it is not only the lightest of all vapours, in the common acceptation of that term, but the lightest of all gases except hydrogen and ammonia. To this circumstance the soft and tender beauty of the clouds of an atmosphere is mainly to be ascribed. The *sphericity* of the cloud-particles may be immediately inferred from their deportment under the luminous beams. The light which they shed when spherical is *continuous;* but clouds may also be precipitated in solid flakes, and then the incessant sparkling of the cloud shows that its particles are *plates* and not spheres. Some portions of the same cloud may be composed of spherical particles, others of flakes, the difference being at once manifested through the *calmness* of the one portion of the cloud, and the *uneasiness* of the other. The sparkling of such flakes reminds one of the plates of mica in the River Rhone at its entrance into the Lake of Geneva, when shone upon by a strong sun."—Paper read before Royal Society, March 8.

A Form of Actinometer is described by Mr. Louis Bing in the *Photographic News* for February. It consists of a rectangular box, to one side of which a square tube is applied. At the aperture of the tube there is a slide with a rectangular opening, by moving which he can either admit light into or exclude it from the tube. One side of the tube is made of yellow non-actinic glass, and the opposite or interior side is made of white glass. By looking through the yellow glass one can watch the action of the light in the tube by simple inspection. A scale is marked on the strip of white glass by means of a standard tint. The side of the box to which the tube is fixed is made to take off, and is held in its place by means of four little springs, like the back of a dark slide. A cylinder is placed within the box, against which the white glass of the tube is pressed, and which is surrounded with sensitive paper. The top of the box, which has a milled head, is also made to take off. This milled head is fixed to a rod which passes through the cylinder, and by means of which the photographer can turn the cylinder either way. By unscrewing this little top-piece he can remove the milled head, and then the top of the box. The cylinder can also be lifted out of the box for the purpose of charging it with sensitive paper. This is done once, in the morning, for the work of the whole day. After inserting the cylinder the top of the box is replaced, the milled head and its little screw. "Fix the side with the tube, and you have only for every fresh exposure to give a slight turn to the cylinder, by means of the milled head, in order to bring a fresh part of the paper forward, at the back of the white glass."

Electro-Chemistry in Metallurgical Operations.—M. Becquerel has recalled

the attention of the French Academy to a method proposed many years ago by him for the separation of ores containing lead, copper, and silver. The general principle of the method consists in the employment of galvanic "couples" composed of zinc, iron, and lead, associated with plates of copper or a piece of well-baked carbon. The plates of non-oxidable metal or the non-metallic conductive substances are put in immediate contact with the argentiferous metallic solution, whilst the plates of oxidable metal are placed in a permeable diaphragm made with untanned hide. This is filled with salt and water, and the plates are then put in metallic communication with each other. The mineral is placed in the vessel containing the saline solution, and is rapidly stirred by machinery for the purpose. The mineral being deposited, the liquid is decanted into other basins, in which the galvanic couples are placed. Experience has shown, M. Becquerel says, that this process may be well employed for silver ores containing copper and lead, at least when sea-salt is cheap and when sufficient wood exists in the neighbourhood.—Vide *Comptes-Rendus*, March 1.

The Electric Conductibility of Metals has had devoted to it a memoir which has been lately laid before the Berlin Academy of Sciences by Herr Paalzow. The paper is one of interest. The experiments recorded by the author are numerous, and the results obtained are of some importance. Many of them confirm the views formerly expressed by Beetz. Herr Paalzow concludes from his researches that there is no relation between the conductibility for heat and that for electricity. He has experimented on the following substances, and found that they have the following order in point of conductibility of heat and electricity:—Heat: Mercury, water, sulphate of copper, sulphuric acid, sulphate of zinc, solution of sea-salt. Electricity: Mercury, sulphuric acid, solution of sea-salt, sulphate of zinc, sulphate of copper, water.—Vide *L'Institut*, Feb. 27.

The Mechanical Descent of Glaciers.—The Rev. Canon Moseley, who has been studying the movement of glaciers, has inquired into the forces which impede the descent of these masses of ice, and thus summarises them:—1st. The resistance to the sliding motion of one part of a piece of solid ice on the surface of another, which is taking place continually throughout the mass of the glacier, by reason of the different velocities with which its different parts move. This kind of resistance will be called in this paper (for shortness) *shear*, the *unit* of shear being the pressure in pounds necessary to overcome the resistance to shearing of one square inch, which may be presumed to be constant throughout the mass of the glaciers. 2ndly. The friction of the superimposed laminæ of the glacier (which move with different velocities) on one another, which is greater in the lower ones than the upper. 3rdly. The resistance to abrasion, or shearing of the ice, at the bottom of the glacier, and on the sides of its channel, caused by the roughness of the rock, the projections of which insert themselves into its mass, and into the cavities of which it moulds itself. 4thly. The *friction* of the ice in contact with the bottom and sides so sheared over or abraded. He has gone into a mathematical calculation of the value of these forces, and he considers, as the result of his inquiries, that the weight of a glacier is insufficient to account for its descent—that it is necessary to conceive, in addition to its weight, the operation of some other and much greater force, which

must also be such as would produce those internal molecular displacements and those strains which are observed actually to take place in glacier-ice, and must therefore be present to every part of the glacier as its weight is, but more than thirty-four times as great.

The Magnetism of Chemical Combinations.—Herr Wiedemann has laid a paper on this difficult problem before the Academy of Berlin. Working on the principle that the salts of metals showing magnetic properties possess those properties in some degree, Herr Wiedemann has found that "in all the salts of the same metal which are in an analogous combination, the product of the temporary magnetism excited by the magnetic force in the unit of weight of the salt by its atomic weight is a constant number; or, in other words, that the magnetism of an isolated atom of one of these salts is constant. Salts in the solid state give nearly always the same result, especially when they contain water of crystallisation. In case these solid salts contain no water of crystallisation, their atomic magnetism is generally a little more feeble: this is especially seen in the case of the anhydrous salt of copper. The magnetism of the salts of copper is peculiar, especially the bromide; for here there are two diamagnetic bodies combining to form a magnetic compound."

Temperature and Refraction.—The importance of considering the relation between these two conditions was well shown in a paper addressed to the French Academy quite recently by M. Faye, who has been writing on the subject of astronomical errors of observation in this paper. M. Faye said that, with the astronomical instruments of Gambey, we obtained not only an immediate estimate of seconds, but even of the tenths of seconds; and it is, he observed, by seconds that the errors of observations are to be recorded, especially observations by reflexions in the mercury bath. M. Faye, in trying to discover the causes of errors (not merely due to personal observations), thinks he has discovered them in the very imperfect manner in which the corrections for refraction are made. In the observatory of Greenwich, for example, he said, the external temperature is considered, but not the temperature of the room in which the observations are being conducted; this, he said, was a most fertile source of error.—Vide *Comptes-Rendus*, March 8.

What is meant by the term "Catharism?"—At a recent meeting of the Chemical Society of London, Mr. Charles Tomlinson explained the sense in which he applied the new term "catharism" (from *καθαρός*, *pure* or *clean*), distinguishing between "clean" in its ordinary and in its chemical sense. The finger could not be made chemically clean by any process, whereas a glass rod, cleansed with strong acids or alkalies, and well washed, was chemically clean, and no longer possessed the power of liberating either salt or vapour from liquids. The action of solid bodies in determinating these changes he ascribed to the greasy film which, after exposure to the air, they are sure to acquire. For this film, the adhesion of the solid or vapour is greater than it is for the glass, and hence the effect of the solid. To such chemical uncleanness all phenomena of this kind should, he thought, be ascribed, and he defined a nucleus as a body which "has a stronger adhesion for the gas, or the salt, or the vapour of a solution, than for the liquid which holds it in solution." He repudiated the notion that temperature has

anything to do with the phenomenon of supersaturation, and described experiments in which supersaturated solutions of various salts were kept for hours in catharised vessels at a temperature of 10° F., without crystallisation taking place.—*Scientific Opinion*, March 17.

The Life of Faraday.—In the *Proceedings of the Royal Society* (No. 106) Dr. Bence Jones has written a very touching biography of Faraday. It differs from Dr. Tyndall's sketch in being made up in great part of Faraday's letters, and in being divided into chapters corresponding to each year of his life.

An Electric Clock.—The following is the specification of a patent quite recently taken out by Mr. R. C. Rapier of Westminster. Two or more breaks are employed for the purpose of making simultaneous contact, the object being to secure certainty of action. In order to hang a pendulum, a bar of steel or other metal, with one edge turned up, is supported on a frame. The pendulum stem does not reach quite up to this bar, but is suspended on it by two cheeks or plates fastened to the sides of the stem of the pendulum. This bar is fitted with a stud or pin midway between the cheeks, and on this pin turns a friction roller which offers far less resistance to the working of the pendulum than any kind of dead collar would do.

Hydrogen and Palladium.—Perhaps the greatest physico-chemical discovery of the quarter is that by Professor Graham, of the undoubted metallic qualities of hydrogen. The Master of the Mint has demonstrated that hydrogen when absorbed by palladium combines with it to form an alloy. The following account of one of the experiments lays the result before our readers, the hydrogen being termed hydrogenium. *Experiment* 1.—The wire had been drawn from welded palladium, and was hard and elastic. The diameter of the wire was 0·462 millimètres; its specific gravity was 12·38, as determined with care. The wire was twisted into a loop at each end, and the mark made near each loop. The loops were varnished, so as to limit absorption of gas by the wire to the measured length between the two marks. To straighten the wire, one loop was fixed, and the other connected with a string passing over a pulley, and loaded with 1·5 kilogramme, a weight sufficient to straighten the wire without occasioning any undue strain. The wire was charged with hydrogen by making it the negative electrode of a small Bunsen's battery, consisting of two cells, each of half a litre in capacity. The positive electrode was a thick platinum wire placed side by side with the palladium wire, and extending the whole length of the latter within a tall jar filled with dilute sulphuric acid. The palladium wire had, in consequence, hydrogen carried to its surface for a period of one and a-half hours. A longer exposure was found not to add sensibly to the charge of hydrogen acquired by the wire. The wire was again measured, and the increase in length noted. Finally, the wire being dried with a cloth, was divided at the marks, and the charged portion heated in a long narrow glass tube kept vacuous by a Sprengel aspirator. The whole occluded hydrogen was thus collected and measured; its volume is reduced by calculation to Bar. 760 millims., and Therm. 0° C. The original length of the palladium wire exposed was 609·144 millims. (23·982 inches), and its weight 1·6832 grm. The wire received a charge of hydrogen amounting to 936 times its volume, measuring 128 cubic centims., and therefore weighing 0·01147 grm.

When the gas was ultimately expelled, the loss, as ascertained by direct weighing, was 0·01164 grm. The charged wire measured 618·923 millims., showing an increase in length of 9·779 millims. (0·385 inch). The increase in linear dimensions is from 100 to 101·605; and in cubic capacity, assuming the expansion to be equal in all directions, from 100 to 104·908. Supposing the two metals united without any change of volume, the alloy may therefore be said to be composed of:—

	By volume.	
Palladium	100	or 95·32
Hydrogenium	4·908	or 4·68
	104·908	100

ZOOLOGY AND COMPARATIVE ANATOMY.

The Formation of the Blastoderm in Crustacea.—The fine memoir of MM. Van Beneden and Bessels on this subject, which was lately presented to the Academy of Belgium, and an abstract of which was given by the authors in the *Monthly Microscopical Journal*, has been reported on to the Academy by the veteran physiologist Schwann. The following is a part of M. Schwann's report. With regard to the formation of the blastoderm in the Crustacea examined, the authors distinguish two types: in the first, the blastoderm is preceded by the total segmentation of the vitellus, which first divides into two portions, each portion again dividing into two, etc. The authors have occasionally observed a globe divide itself into four portions instead of two. In this case the nucleus first divides itself into four parts. The last globes which result from these successive divisions, and which, in my opinion, are true germ cells without membrane, are of a pyramidal shape; the base of the pyramid is inclined towards the surface of the egg, towards the chorion, the apex towards the centre. They are full of nutrient globules. Before the segmentation is completed, the globules pass towards the apex of the pyramids, then towards the centre of the egg, while the base of the pyramids, which touches the chorion and contains the nucleus, becomes transparent. This base finally separates itself by stricture from the summit, and constitutes the blastoderma, while the apices form a nutrient non-cellular mass—the plasma—in the blastodermic vesicle. This plasma may be subsequently split up by a totally different operation to that of the segmentation of the vitellus. In the second type of the formation of the blastoderm very different phenomena present themselves. At a given point of the surface of the vitellus a few large cells present themselves. They multiply by division, commencing with the nucleolus; then the nucleus divides; and then the protoplasm of each cell. These cells being but few in number, form a small zone under the chorion; this zone spreads, and finally encircles the vitellus, which is thus placed in the centre. M. Édouard van Beneden, by an ingenious theory, succeeds in reconciling these two types of the formation of the blastoderm, although they appear to differ so widely. The vitellus is composed, as we have already said, of the protoplasm of the cell-egg and of the plasma—that is to say, of the nutrient

globules of the future embryo. After fecundation these two elements separate, and the difference of the phenomena arises from the fact that in certain animals the separation takes place *after* the segmentation of the cell-egg, in others *before* the segmentation.—*Scientific Opinion*, February.

Fauna of the Gulf-Stream.—The American Superintendent of the Coast Survey recently ordered a number of investigations to be made on this point, and a certain amount of work in this direction has already been accomplished. The line of the present survey was "in a section between Key West and Havana, incidentally with the purpose of sounding out the line for the telegraph cable." Although the work was interrupted, and the casts made with the dredge few, "the interesting fact was disclosed that animal life exists at great depths, in as great a diversity, or as great an abundance, as in shallow water." By two casts in two hundred and seventy fathoms off Havana, crustacea and worms, numerous dead shells of gasteropods and pteropods, living terebratulæ, and seven species of bryozoa, besides echini, star-fishes, and an abundance of corals, hydroids, and foraminiferæ, were taken. Only one species of seaweed, however, was mixed with this luxuriant animal life, which corresponds with similar results of deep-sea dredging in the European seas, and shows that "the greater number of deep-sea animals must be carnivorous."—Vide *Bulletin of the Museum of Comparative Zoology*, No. 6.

Animal Life in water at great pressure.—In proof of Dr. Carpenter's idea that the pressure of water has little effect on the vitality of animals, M. Deville has at his laboratory an apparatus erected by M. Cailletet, in which fishes are living under a pressure of 400 atmospheres, proving that the greatest depths of the ocean may be habitable.

The Horse in pre-Historic times.—In his paper this year communicated to the Royal Society on the fossil equine remains of the Cave of Bruniquel, Professor Owen states that the sum of the several comparisons was to refer the equine fossils from sedimentary deposits, and both varieties from the Bruniquel cave, to one and the same species or well-marked race belonging to the true horses, or restricted *Equus* of modern mammalogists; the individuals of which race, with a small range of size, probably due to sex, were less than the average-sized horse of the present period, but larger than known existing striped or unstriped species of *Asinus*, Gray.

Lymphatic Vessels in the tail of Batrachians.—An abstract of a paper on this subject by Herr Langer appears in a recent number of *L'Institut*. Herr Langer has found that, in addition to the canals which can be detected by injection, there are very many other lymphatic vessels which pass from the part where the injection ends to the border of the fin. These borders are clearly defined, rectilinear, and without dentations. The general character of walls, and the form of the nuclei in them, differ very little from those of the capillary blood-vessels. The limiting envelope of these lymphatic vessels are, according to Herr Langer, very readily observed. In many places they may be seen freely anastomosing. He states that those lymphatics which end in a *cæcum* may seem to arise from the walls of the capillary vessels where they, as it were, start from a nucleus. Herr Langer thinks that there are many other points in this branch of histology which remain to be worked out.—Vide *L'Institut*, Feb. 27.

The Zandr (*Lucio Perca Zandr*).—Mr. Frank Buckland, writing in *Land and Water*, states that he has received a specimen of the German fish, the "Lucio Perca Zandr." The zandr is also known by the name of the "Pike Perch." In external appearance it resembles both the pike and the perch, the scales being particularly perch-like; the weight of his fish was, when caught alive, 6½lbs.; its length 24 inches. Herr Brockhardt, one of the principal purveyors of good things in Berlin, has stated that he shall be very glad to send him next spring a living zandr of 11lb. or 12lb. weight, and will also procure young zandr and transmit to this country. Zandr of three to four inches long are to be had in February and March. It is, he believes, essentially a lake fish, and is not known to the west of the Elbe. Although it may be called a river fish, it appears to flourish only in the lake-like extensions of the Naffel, Spree, and other rivers of this part of North Germany. It is considered a great delicacy in Berlin.

The Zoological Society.—The papers read before this active society during the past quarter have been both numerous and important. The following is a brief summary of some of the principal communications, given with a view of enabling our readers to see whether any work has been done on their particular subject:—Mr. Sclater read a paper on a collection of birds from the Solomon Islands, which he had recently received through the courtesy of Mr. Gerard Krefft, Curator and Secretary of the Australian Museum, Sydney, N.S.W. The collection was stated to be one of great interest, embracing twenty-one species, three of which appeared to be previously undescribed. One of these, a new species of Grakle, was proposed to be called *Gracula Kreffti*. In concluding his paper, Mr. Sclater made remarks upon the general character of the Fauna of the Solomon Islands, which were shown to belong zoologically to the Papuan or Austro-Malayan Sub-region of the Australian Region.—Mr. Sclater also read the third part of a series of papers on the birds of the vicinity of Lima, Peru, with notes on their habits by Prof. W. Nation, C.M.Z.S., of Lima.—Dr. J. E. Gray communicated a memoir on the families and genera of Tortoises, Terrapins, and Turtles, and on the characters afforded by the study of the skulls of these reptiles.—Dr. J. Murie read a note on the sublingual aperture and sphincter of the gular pouch in the Great Bustard (*Otis tarda*), as observed in an adult example of this species which had recently died in the Society's menagerie.—Dr. Murie read also a report on the skulls of the Eared Seals (*Otaria*) collected by Lecomte, the Society's keeper, in the Falklands, which were shown to belong to two species, *Otaria jubata* and *O. nigrescens*.—Mr. W. H. Flower read a note on the substance ejected from the stomach of the male Wrinkled Hornbill (*Buceros corrugatus*) lately living in the Society's Gardens, concerning which a communication had been made to the Society by Mr. Bartlett at a previous meeting. Mr. Flower stated that the envelope in which the ejected food was contained, consisted of the entire epithelial lining of the stomach of this bird.—A communication was read from Prof. Owen, F.R.S., "On Dinornis," forming the fourteenth part of his series of memoirs on this subject. The present paper related chiefly to the craniology of the genus; but contained also the description of a fossil cranium from the London clay of Sheppey, in the collection of the Earl of Enniskillen, F.R.S., which Prof. Owen considered

to present combinations of Dinornithic and modern Struthious characters, and which he characterised, as belonging to a new genus and species of fossil birds, under the name *Dasornis Londinensis*.

South American Oxen.—At a very recent meeting of the French Academy of Sciences, M. de Quatrefages presented a memoir written by M. Sanson on a peculiar group of oxen found in South America. The cranium of this supposed new family has been examined, and various naturalists who have seen it have regarded it as a monstrosity. But M. Sanson says that if it is a monstrosity it is capable of perpetuating itself, since it is represented in South America by large flocks of cattle. In Mexico it is particularly abundant, and, thanks to a correspondent in that country, M. Sanson has obtained photographs of the new species.—*Comptes-Rendus*, March 8.

The Digestive System in Orthoptera forms the subject of a memoir presented to the *Kaiserliche Akademie* of Vienna, by Herr Von Graber. The ventriculus and pro-ventriculus have been especially dealt with in this memoir, which has as yet only been published in abstract.

A New British Leech.—Some time ago Dr. J. E. Gray announced the discovery in this country of *Trocheta subviridis*. Nothing was since heard of the presence of this annelid. But now Mr. Henry Lee and some of his friends have established beyond question that it is a British species. A long account of the discovery is to be found in *Land and Water*, March 13, by Mr. Henry Lee.

The Pacinian Corpuscles.—The structure of these bodies has been studied by Professor Ciaccio, who has just published a long and admirably illustrated memoir upon it. The conclusions arrived at are chiefly as to the relation of the nerve to the club-shaped centre. This relation is one, according to the author, of continuity. He does not admit the existence of either a loop or a coil.

The Tissues of the Sponge.—Some curious experiments on the grafting of sponges one on the other were lately made by M. Léon Vaillant. He conducted his observations principally on *Tethea lyncurium*, and found that the vitality of its cortical is greater than that of its medullary substance. Grafting from individual to individual is easily effected.—*Comptes-Rendus*, January.

The Graphic Method Applied to the Movements of Insects.—M. Marey has been making the wings of insects record their form and rapidity of movement, something in the way in which he has made the heart do the same thing in his cardiograph.

Fresh-water Crustacea.—Those who can procure abundance of cray-fish will be glad to know where they can find an elaborate memoir on the anatomy of this animal. They should consult the *Annales des Sciences Naturelles*, tome x. 1868.

Triarthra longiseta.—An interesting paper, accompanied by a plate, on this species appears from the pen of Dr. C. T. Hudson in the *Monthly Microscopical Journal* for March.

A New Infusorium, to which its discoverer, Mr. J. G. Tatem, has given the name of *Vasicola ciliata*, has been described in a paper in the *Monthly Microscopical Journal* for February. A coloured plate delineates the different stages of development and various phases of life of the new creature.

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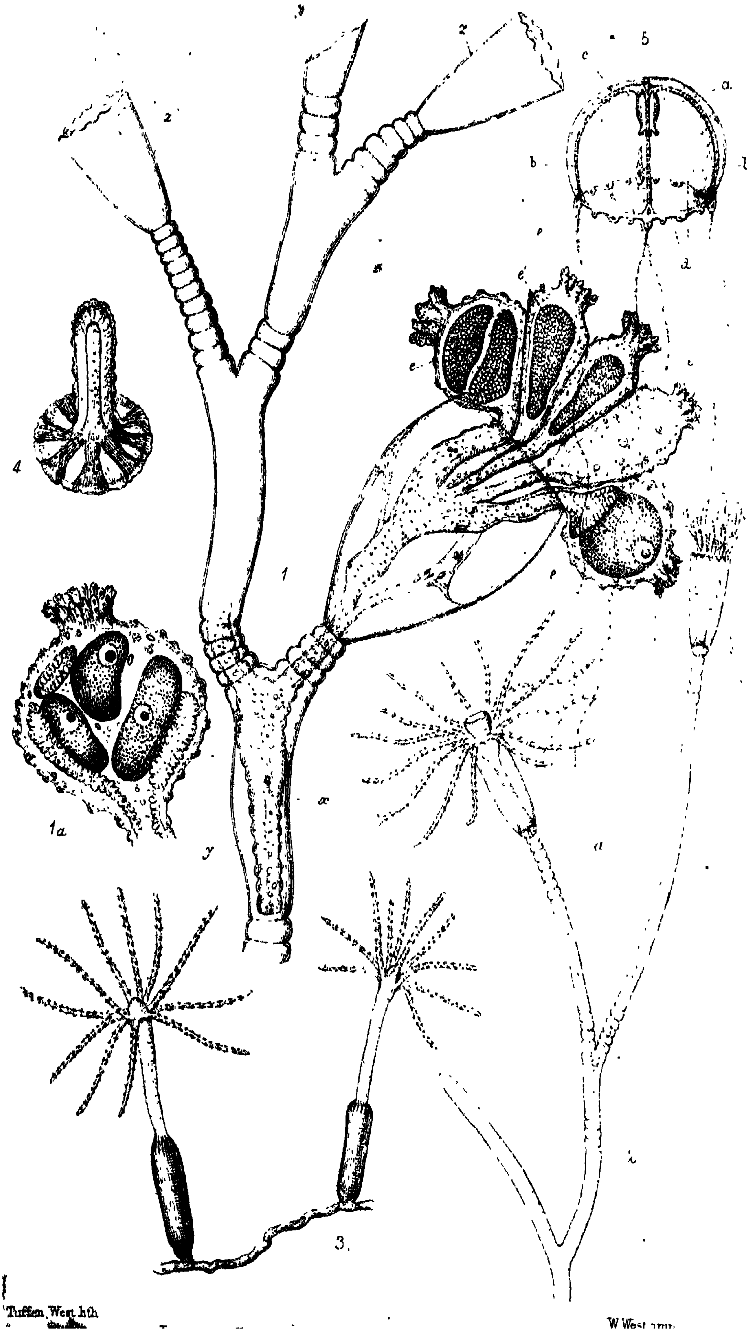
Plate XLV



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THE SERTULARIAN ZOOPHYTES OF OUR SHORES.

BY THE REV. THOMAS HINCKS, B.A.

[PLATES XLV. and XLVI.]

AMONGST the rejectamenta which strew the shore after a fresh breeze and a rough tide, there are few things more likely to arrest the eye and win the admiration, even of the least observant, than the corallines, which mingle their light and flexile forms with the tangled masses of weed or lie in graceful tufts upon the sand. With the uninitiated, their plant-like configuration passes as conclusive evidence of their vegetable nature; and the non-scientific world now, like the men of science of a century ago, receives the doctrine of their animality with incredulity. And indeed we cannot wonder at the scepticism; for so complete is the imitation of vegetable form in these beings, and so vegetative in many respects is the fashion of their life, that there is nothing to suggest a doubt, on a slight and superficial acquaintance, as to their affinities. The skeletons only of the zoophyte commonly fall in the way of the amateur collector on the shore, and these, intermingled with the Algæ, and resembling nothing so much as miniature shrubs and trees, offer no sufficient clue to the interpretation of its history.

We propose to give a general sketch of one section of our British zoophytes—the section that embraces the largest and most familiar kinds, and of which the common *Sertularia* is a typical member. The interest excited by the beauty of their plant-like forms will be deepened by a knowledge of their structure and economy. Indeed we first attain an adequate conception of their beauty when we study them in the living state, and recognise the plain proofs of their animal nature in the multitude of polypites that now display their wreaths of milk-white tentacles, like blossoms on a tree, and now withdraw in sudden haste within the shelter of their cup-like dwellings.

Zoophyte is an old-fashioned and somewhat vague term, but not without its use as a convenient popular designation of the extensive tribe in which, though the attributes of the two kingdoms are not blended as the elder naturalists fancied, the vege-

table aspect combines with an animal structure. Its scientific equivalent is found in the term *Cœlenterata*, the name which the able German physiologists Frey and Leuckart have bestowed on the sub-kingdom, under which they have ranged a portion of the miscellaneous contents of Cuvier's *Radiate* division. The establishment of this new province is one of the later results of zoological research; and though not universally recognised, it may be said to have made good its place amongst the primary departments of the animal kingdom.

The Cœlenterates are distributed under two principal groups, the *Hydrozoa* and the *Actinozoa*; the former including the *Hydra* and its immediate kindred, the Hydroid Zoophytes, to which the tribe belongs that is the subject of this paper; the free-floating oceanic forms, of which the *Velella* and the Portuguese man-of-war (*Physalia*) are familiar examples; and the large "blubbers" or jelly-fish that often crowd the surface of the sea or strew the beech in autumn: the latter embracing the sea-anemones and their coral-making relatives, &c.

We propose to deal at present with that section of the Hydroid Cœlenterates in which most of the exquisite corallines that are likely to fall in the way of our readers during their visits to the sea-side find a place. Between the plant and these plant-like beings there is not merely a close resemblance in external form; there is also a striking analogy in some respects between the life of the two. The Hydroid embryo, driven through the water by the action of a thousand invisible paddles, comes to rest at last on some point of the rock, on the shell of some mollusc, or on the surface of some broad Laminarian frond. There it attaches itself, discarding its locomotive appendages, and enters upon a course of development which reminds us forcibly of the mode of growth in the vegetable kingdom. It first expands into a circular disc, from the centre of which rises an upright stem, the whole structure being now clothed with a delicate horn-like investment. (Plate XLV. fig. 4.) The upper extremity of the stem enlarges, and is gradually developed into a hydraform zooid or polypite, which may be regarded as the equivalent of the leaf-bud. After a time the ascending stem puts forth other buds, which become polypites, or branches bearing them, and these branches give off their branchlets, and the polypites continue to multiply like leaves upon the tree; and this vegetative process proceeds until the simple primary shoot has expanded into the lovely arborescent structure which the sea has torn from its attachment and flung at your feet. At the same time other changes have been going on. The disc by which the nascent zoophyte is fixed in its place sends out thread-like prolongations, which creep over the surface that supports it, like delicate rootlets, and from the net-work thus formed new shoots arise by a process of repeated budding, until at last a

miniature forest surrounds the original stock, united with it in one compound organism and sharing a common life. In some of the large foreign species, the tree-like shoots attain a height of two or three feet, and bear some millions of polypites, all evolved by continuous gemmation, and the offspring of a single germ. These facts in the history of the zoophyte have their parallel in that of the plant. The multitude of polypites united in one organism answers to the myriads of leaves upon the tree, and in both cases the manifoldness is due to successive buddings. Other correspondences will appear as we proceed.

All the zoophytes belonging to the tribe now under consideration are composite beings in their adult state. They form communities of greater or less extent, the organisation and economy of which we shall endeavour to explain. The horny tree-like tufts which we gather on the shore are the external skeletons, as it were, of the zoophyte. They consist of ramified tubular cases, which inclose and protect the soft portions of the animal. Examined with care, the stems and branches are found to bear at intervals small cup-like receptacles, which give them a serrulated appearance (Plate XLVI. fig. 1*a*). These are known as the *calycles*, and serve as the homes of the multitude of minute *Hydræ*, that combine in these composite organisms to form a kind of federal republic (Plate XLV. fig. 1*z*). Through the entire extent of the tubular investment, a thread of animal substance passes in the living state, pervading every minute branchlet, and linking together as one organic whole the tenants of the many calycles scattered over the structure. This common flesh (*cœnosarc*) (Plate XLV. fig. 1*x*), permeating the principal stem and ramifying through every portion of the arborescent shoots, is the essential part of the zoophyte. The horny cuticle (Plate XLV. fig. 1*y*) is an excretion from its surface; the hydræ bud from it, and when destroyed are renewed from its prolific pulp; and penetrating its substance throughout runs the cavity in which the nutrient juices circulate. This central canal extends to the base of the calycles, and there communicates with the stomachs of the hydræ, from which the food captured and digested by them passes into it, and is distributed through the organism (Plate XLV. fig. 2*a*). The alimentary zooids, to which is assigned the office of purveyors to the commonwealth —that procure and prepare the pabulum on which the healthy development of the colony depends—are structurally identical with the *Hydra* of our fresh waters, and are known in the terminology of the Hydroida as the *polypites* (Plate XLV. figs. 2, 3). They are lodged in the calycles,* which we have

* The presence of a calycle or protective *theca* for the polypites is characteristic of that section of the zoophytes to which this paper is devoted

described; from these they spread forth their wreaths of tentacles in search of food, and here they find shelter when alarmed. They exhibit a very simple structure; the body is soft and contractile, containing an ample digestive cavity, hollowed out, as it were, in its substance, which communicates through an orifice *below* with the general cavity of the cœnosarc, and *above* terminates in an oral aperture, around which are ranged in a single series a number of filiform tentacles. The polypite is in fact a laboratory of the simplest construction, in which nutriment is prepared for distribution through the commonwealth. The only approach to complexity of organisation is found in the prehensile arms, which are not mere extensile threads for entangling prey, but are furnished with an armature of poisoned darts, and not only arrest but paralyse their victims.

If we examine the soft body-substance of the zoophyte, we find it to consist of two layers, an outer (*ectoderm*) and an inner (*endoderm*), the latter lining the whole of the interior cavity, and the former constituting the outer integument. These elements enter into every part of the structure. The common flesh that pervades the horny coralline, and upon which it has been moulded, is a simple tube bounded by these two layers: the body of the polypite is a somewhat enlarged extension of this tube, slightly modified, and the tentacles are slender prolongations of it. The *endoderm* is chiefly concerned with nutrition, and its inner surface bears the multitude of cilia, which by their incessant movements maintain the circulation of the fluids in the general cavity of the body. The *ectoderm* is a structureless layer of contractile substance, closely resembling the *sarcode* of inferior organisms, and betraying its affinity with it in certain genera, by sending out extensile processes, like any Rhizopod, which can be completely withdrawn into the masses from which they originate. Such is the building material of which the Hydroid organism is composed. In the outer layer are lodged the organs of offence, which are known as *thread-cells*, and which are very characteristic of Cœlenterate structure. Mounted on prominent nodules distributed along the tentacles, and concentrated in batteries at various points of vantage, these formidable projectiles give the Hydroid colony immense facilities for the capture of food. The thread-cells consist of minute sacs embedded in the flesh, and enclosing long

(*Thecaphora*). In another division (*Athecata*) the polypites are *naked*, though the common flesh is more or less invested by a horny covering or polypary; while in the remaining sub-order (*Gymnochroa*), of which the *Hydra* is the sole representative, there is no hard integument whatever, and the polypites are single and locomotive.

thread-like darts, that can be projected with much force, and appear, from their deadly effect, to poison as well as to wound. They exhibit many variations, and are most interesting objects of study to the microscopist.

We have referred to the circulation that takes place within the tubular cavity of the cœnosarc, by which the nutriment prepared by the polypites is distributed through all portions of the colony. A stream of granular matter traverses the whole of the complex structure, entering the thousand stomachs of the alimentary zooids, and mingling with their contents; then rushing from them, laden with the chyme, and bearing it through all the ramifications of the cœnosarc. After flowing downwards for some time, the stream pauses for a few seconds, and then courses back again, and again enters the storehouses in which the prepared nutriment is lying. It is most interesting to watch the torrent of granules flowing rapidly through the multitudinous canals and runlets, the incessant flux and reflux, the busy ferment within the digestive sac, the sudden exodus, and the impetuous return.

The movement of the fluids is no doubt largely due to the agency of cilia; but the phenomena of the circulation amongst the Hydroids require further investigation, in the course of which light might probably be thrown on some interesting points in physiology. So much as to the nutrition and building up of the Hydroid colony.

The pretty plant-like skeletons, then, which we collect on the shore, exquisite as they are in form, give us no idea of what the zoophyte really is. To appreciate its beauty, no less than the marvels of its organisation, we must see it in life, when every graceful calycle has its tenant; when the whole structure wears the indefinable expression that only vitality gives; we must watch the *quasi* blossoms expanding, and admire the wreaths of embossed tentacles, drooping over the margins of the crystal cups; we must note the buds that are being gradually moulded into polypites in various portions of the colony, and that will soon burst into active life and take their part in providing for the support of the community to which they belong; and looking through the transparent walls of stem and branch, we must mark the life-giving stream, laden with the products of a thousand busy workers, in its ceaseless ebb and flow.

We have seen how the Hydroid organism is enlarged by a purely vegetative method; how branch after branch buds from the main stems, and fresh polypites spring from branch and branchlet, to supply the increased demand for food, until the primary stem with its solitary zooid has expanded into the clustered colony with its forest of tree-like shoots and its million of associated Hydræ.

But the diffusion of the species is secured by a true sexual reproduction; and a peculiar interest attaches to this portion of the life-history of the zoophyte. Here again we trace a striking analogy to the phenomena of plant-life. At certain seasons, besides the buds that are developed into polypites, others make their appearance on the zoophyte, which are destined to originate and mature the seed of new colonies, and correspond with the flower-bud of the plant. The alimentary and reproductive functions are distributed amongst two classes of zooids; one provides for the existing commonwealth, the other lays the foundations of new communities. In the tribe now under consideration, these reproductive buds are always inclosed in horny capsules, which are distributed over the branches amongst the calycles, and often exhibit the most graceful urn-like shapes. In some cases the reproductive zooids continue permanently attached like the polypites, and the embryos, when mature, escape from them into the water. They may be described as closed sacs, into which the general cavity of the body extends, so that they are freely visited by the nutrient currents; and between the two layers that compose the walls of the sac, as of every other portion of the Hydroid organism, the generative elements are produced. These fixed reproductive sacs are structurally identical with the polypite up to a certain point; but the portions of structure that are essential to its half-independent existence, the mouth and tentacles, are suppressed in the sexual zooid. It receives its nutriment from the general circulation, and devotes its energies, not to the capture of food, but to the elaboration of the reproductive elements. Several of these buds, borne on an offshoot from the cœnosarc, are usually met with in the capsule, which protects them through the course of their development, and allows free egress to the embryo, when mature. (Plate XLVI. fig. *5oo*).

The sexual members of the Hydroid colony are not always, however, of so humble a structure, nor do they always maintain their connection with the community. In many genera they take on a highly complex organisation, and lose the sedentary habits of their tribe; they are furnished with the means of locomotion, and simple organs of sense, and at a certain point of their development detach themselves from the parent stock, and lead a free and active existence, during which they fulfil their functions and then perish. These free sexual zooids exhibit a form of structure, no less than a mode of life, which contrasts strikingly with that of the plant-like zoophyte and its ordinary polypites. (Plate XLV. fig. 5.) They consist of a somewhat cylindrical and sac-like body (Plate XLV. fig. *5a*), suspended in the centre of a filmy transparent bell, which acts as a float, and bears it up, while, by its contractile movements,

it propels it through the water. From the margin of the bell depend a number of extensile tentacles, and a delicate membrane partially closes it below. The central body is furnished with a mouth at its free extremity, and contains a digestive cavity, which communicates with four canals that traverse the substance of the bell and empty themselves into a circular vessel running round its margin. On detaching themselves from the colony, and emerging from the capsule, these vagrant members, driven by their contractile swimming-bells, dance gaily through the water, and exhibit, on a casual inspection, not a trace of their affinity with the rooted and vegetative being from which they have but lately parted.

Their structure is that of the jelly-fish, and for a long time they were separated, in the systems of zoology, from their own kindred, and banished to a distinct class. When their escape from the capsule of the zoophyte was first observed, they were regarded as the embryo, and it was a marvel and mystery that the child should be so totally unlike its parent. The marvel has now vanished, and the mystery is solved; but the simple facts, as interpreted by science, have all the interest of a romance. It was on a false reading of these facts amongst others that Steenstrup's ingenious theory of "the alternation of generations" was founded; a theory that captivated by its novelty, while the imaginative dress in which it was clothed gave it an additional charm; but which rests on a complete misconception of the Hydroid economy.*

The locomotive medusiform member of the Hydroid colony, which discharges the sexual functions, is, in fact, a swimming polypite—a modification of the structure that appears in the alimentary zooid, and not built upon a different type. It is essentially a polypite, with its tentacles united by a membranous web, which acts as a float and propulsive organ. A few elements are superadded to those that are present in the ordinary polypites; ocelli and other rudimentary organs of sense are sometimes set along the margin of the bell (Plate XLV. fig. 5*e*), and a circular vessel runs round it, which combines with the radiating canals to form a simple circulatory system; but the basis of structure is the same in both. The medusoid, or locomotive sexual zoöid, is a polypite adapted to a free existence, but effectually disguised by its adaptive dress.

It may be remarked that the superficial dissimilarity between the fixed and floating members of the Hydroid colony is not greater than that between the leaf and flower-bud of the plant, with which they in some measure correspond.

* Dr. Carpenter was the first (in a remarkable paper published in 1848) to challenge this theory, and to appreciate the real significance of the facts on which it is based.

Between the fixed reproductive bud, which in some genera originates and matures the ova, and the vagrant members that we have just described, a series of transitional forms is met with, uniting the one structurally with the other. In some cases a near approach is made to the medusiform structure, and the sexual zooid appears to be on the high road to independent existence, but development is arrested, and it remains attached to the parent stock until the embryos are liberated. Occasionally it even passes beyond the orifice of the capsule (Plate XLV. fig. 1*ee*), and hanging there like a ripe seed-vessel, discharges its contents and then withers away.

Most beautiful in form, colour, and motion are these floating polypites—these *quasi* flower-buds and seed-bearers of the plant-like zoophyte! The umbrella or swimming organ, often of most exquisite shape, is now clear as crystal, and now delicately tinted; the pendent body within is frequently adorned with the gayest colours; the margin of the bell is fringed with the tentacles, which hang in spiral coils or stream through the water in graceful curves: and the whole bubble-like structure floats dreamily, like a balloon suspended in mid-air, or is borne rapidly onward by the pulsations of the contractile disc. The contrast is complete between its habit of life and that of its sedentary kindred.

The medusoids (to use a common but somewhat misleading term) often increase greatly in size and complexity of structure after their liberation from the colony, changing their aspect so entirely that it is difficult to identify them in their early and later stages; they bud off, like the common Hydra, large numbers of young, which become detached; and finally they elaborate the ova and spermatozoa, and having scattered the seed of new generations, they perish. Like the flower of the plant, they are in all probability comparatively short-lived. Their numbers are immense; at certain seasons of the year they swarm near the surface of the sea, and contribute in no slight degree to produce the beautiful phenomena of phosphorescence.

The ova are developed into somewhat elongate ciliated embryos (*planulæ*) (Plate XLV. fig. 1 *e′e′*), which on escaping from the ovary enjoy a term of free existence, and then pass through the course of development described on a previous page, and give rise to the tree-like colony. They remind us of the winged seeds of the plant.

Amongst the family of the *Sertulariidæ*, and some other sections of the Thecaphora, the reproductive buds are always *fixed*; but in the beautiful group of the *Campanulariidæ* (*vide* Plate XLV.), reproduction by free zooids is of common occurrence.

After this rapid sketch of the life-history of the zoophyte, we have only space to refer very briefly to a few of the forms most

characteristic of our coasts, and most likely to fall in the way of the visitor to the sea-side. Various species of *Sertularia* (*vide* Plate XLVI.) and kindred genera are sure to occur on any sandy beach, cast in amongst the weed and other spoils of the sea. Their horny colour and arborescent growth at once attract the eye. The structure of the polypary, the arrangement of the calycles, the elegant forms of the urn-like capsules, may be studied to great advantage in these larger kinds. But they are seldom to be found in a living state on the shore. If a mass of the podded sea-weed (*Halidrys siliquosa*), should be met with it should be carefully examined, and will probably be found to be invested by the exquisite plumes of one of the prettiest of British hydroids, the *Aglaophenia pluma*. The alliance between this species and the podded weed is most intimate; and nothing is more common than to find long trailing pieces of the latter thickly covered with the delicate plumous shoots and fibrous network of the zoophyte. It exhibits a peculiarity that is worth noting. Its reproductive capsules are enclosed in a curious pod-like case, formed by the metamorphosis of one of the *pinnæ* or branches; and, on fertile specimens, these cases often occur in lines down each side of the plume. If, however, we wish to see a member of this lovely family in its living state, we must betake ourselves to the rock-pools, on the walls of which, and about the stems of the larger Algæ, we shall readily find either the species just referred to, or one yet more delicate and exquisite, the *Plumularia setacea*, in which almost every element of zoophytic beauty is combined. The drooping pinnæ of this living plume are closely set with milk-white polypites, which now expand their wreathed tentacles, and now contract and fold them together. The capsules are produced in profusion in the axils of the pinnæ, shaped like a graceful flask and transparent as glass, and within them the ova may be studied in all their stages, until they emerge as active embryos. We have before us, in one of these minute beings, the history of Hydroid life "written small." One chapter, indeed, is wanting here; but that one we may find in a neighbouring pool. On the huge waving fronds of the common tangle, which fringe the rocks at low water-mark, and in the adjacent pools, delicate forests of a small Campanularian zoophyte (*Obelia geniculata*) may often be seen standing out clear and sharp against the dark surface that supports them. It is a true member of its family, representing all its grace of form; its calycles, transparent cups borne on ringed pedicels; its stem, a series of curves; its capsule, the counterpart of some Grecian urn. And within the capsule we find our missing chapter; for it is crowded with the (so-called) Medusæ, the sexual members of the colony, soon to leave their birth-place and wander forth to scatter broadcast the seed of new communities. The trans-

parent urn hides no secrets, and we can watch the development and exodus of the contained zooids without difficulty. The study, we venture to think, will yield more pleasure than many sea-side pursuits. And *Obelia geniculata* is also a phosphorescent species, and at night we may witness the sudden illumination of the colony if we agitate the water in which it is kept.

Another phosphorescent zoophyte is equally accessible; for on almost every coast on which there is rock and weed, the common *Sertularia pumila* may be obtained, overspreading with its dense thickets the larger Algæ, and this will also yield a display of "living stars."

But we cannot multiply illustrations. The shore to which so many hasten at this season will supply them without stint.

DESCRIPTION OF PLATES.

Plate XLV.

Fig. 1. Portion of a shoot of Gonothyræa Lovéni, highly magnified. *x*. The cœnosarc, or common flesh. *y*. The horny cuticle, or polypary. *z z*. Calycles. *e e*. Reproductive buds (gonophores) that have passed beyond the orifice of the capsule, and continue attached externally. *e' e'*. Planulæ, or ciliated embryos.

„ 1*a*. A single gonophore, more highly magnified; showing the ova with germinal vesicle and spot.

From drawings by Professor Wyville Thomson, F.R.S.

„ 2. Campanularia neglecta, highly magnified. *a*. The point where the cœnosarc communicates with the stomach of the polypite.

„ 3. Lafoea pygmæa, highly magnified.

From drawings by the late Mr. Alder.

„ 4. A young Campanularian soon after the attachment of the embryo.

„ 5. The medusiform sexual zooid (gonozooid) of Clytia Johnstoni. *a*. The digestive sac. *b b*. The umbrella, or swimming-bell. *c*. One of the radiating canals. *d*. The circular vessel. *e*. One of the lithocysts (organs of sense).

From drawings by the Author.

Plate XLVI.

Fig. 1. Diphasia pinnata (female), natural size. 1*a*. Portion of a pinna, magnified, bearing a male capsule. 1*b*. Ditto, with female capsules.

„ 2. Diphasia pinaster (female), natural size.

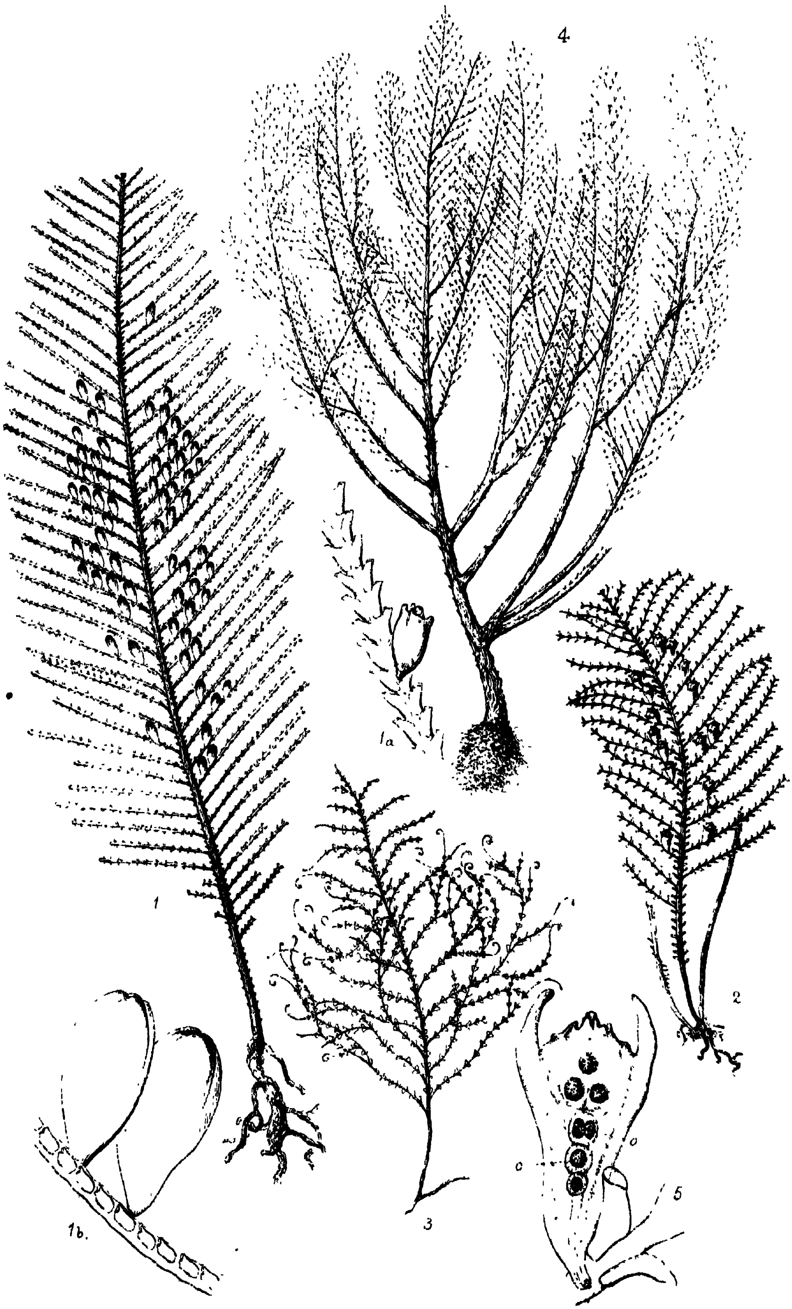
„ 3. Diphasia fallax, natural size.

„ 4. Plumularia frutescens, natural size.

„ 5. Capsule of Diphasia rosacea, showing the fixed reproductive buds (*o o*), with ova.

All the figures but the last are by Mr. Tuffen West.

Plate XLVI



HYDROGENIUM.

BY ROBERT HUNT, F.R.S.

THE attention of experimental philosophers has, for some time past, been gradually drawn to the phenomena presented by the operation of some obscure force, or forces, ever active in the molecular interstices of matter. Under a variety of terms they have been explaining, or rather endeavouring to explain, peculiar attractions manifested by the surfaces of bodies, and assuming different conditions, according to the peculiarities belonging to the surfaces under examination. The force known as capillary attraction—whether exhibited in tubes or between plates of glass—is tolerably familiar to all, and the mechanical power shown by the fibre-tubes of cotton will have been tested by almost every intelligent schoolboy. The absorption of water by a lump of sugar or of chalk, and the "sucking up" of water by a sponge, is so common, that few stop to ask by what power the phenomenon is brought about. We are now, however, beginning to discover that, in these, apparently, simple things, we may observe the opening of a door, disclosing a way, which promises to lead us to a knowledge of nature's most secret operations. The simple adhesion of water to a perfectly clean plate of glass, informs us, that a power resides on that surface; and, if we bring two such surfaces near together with a fluid between them, we see that the fluid is lifted against the gravitating influence of the whole Earth. In this we have hitherto detected a simple mechanical force only. Of late, however, M. E. Becquerel has informed us that this surface force has a power equal to the breaking up of strong chemical affinities. That, metallic solutions being employed, the metal is gradually separated from the solution and deposited in thin films upon the glass plates. In the fine fissures of green-stone rocks we often find films of native copper; and the films of gold in the cracks of the gold-bearing quartz are well known to the miner. These are doubtless due to the force resident on the surfaces of the rocks, in the same way as it is shown in action in M. E. Becquerel's experiment.

The influence of surface is discovered again in the ordinary process of filtration. It was shown by Dr. Hofmann and Mr. Witt, in their report on the water supply in London, that the water which passed through the filter beds of the water companies' reservoirs, was robbed of some portion of the salts held in solution. The late Dr. Normandy, when engaged in his experiments on the production of drinkable water from the sea, discovered that sea water was rendered free from salt, or nearly so, by being filtered through about thirty feet of siliceous sand or powdered glass. The removal of organic colouring matter from water, by passing through a few feet of earth, is another example of the same power in action. These phenomena are shown, yet more strikingly, by charcoal. Hence its employment for purifying water, and its use for removing the annoyances arising from putrefactive fermentation. Experiments have shown that charcoal possesses the power, by virtue of its porosity, of condensing within itself many times its own volume of certain gases and vapours. This property is not peculiar to charcoal—all porous bodies exhibit it to a greater or less degree—but the power is strikingly manifested by this substance. It may be incidentally mentioned here, that Dr. Stenhouse has, by connecting a piece of charcoal with a voltaic battery, and plunging it into a solution of platinum, succeeded in coating all its interstitial spaces with a film of that metal. This is, in itself, another example of the surface action to which it is desired to draw attention. This platinized charcoal possesses all the powers of ordinary charcoal greatly exalted. It acts, indeed, as spongy platinum does, and not only condenses the gases escaping from putrid matter, but combines them with oxygen and slowly burns them away.

An instantaneous light lamp was common enough some years since. Hydrogen gas was produced, by a simple arrangement, by the oxidation of zinc in water, and stored in a bottle for use. When, by turning a stop-cock, a jet of hydrogen gas was projected upon a piece of spongy platinum, it was rapidly condensed and, at the same time, forced into combination with oxygen. The result of this was the production of heat sufficient to ignite the jet of hydrogen gas. Faraday showed how directly this depended on surface action. Taking a piece of perfectly clean platinum, he plunged it into a mixture of oxygen and hydrogen gases. These united to form water on the surface of the metal, and by the heat evolved, in this process, the metal became red hot.

It may appear too much to say that the solution of sugar or of salt in water is an analogous process to those which have been thus hastily and popularly described. A little attentive consideration will, however, carry conviction to the mind, that in the solution of a lump of sugar in water, we see the diffusion of

it, through the interstitial spaces of the fluid, up to the point of saturation; when the solution-power ceases, and that it is a case of a similar nature to the solution of sulphuretted hydrogen in charcoal. Mr. Graham has, long since, beautifully shown the power of this surface force in water. Anyone can repeat a simple experiment, and greatly interested will he be in watching the result. If to a solution of sulphate of copper some liquid ammonia is added, we produce that beautiful purple solution which marks the shop of a druggist. Fill a small bottle with this solution, and, placing a little bit of window-glass over the mouth of the bottle, lower it, by means of a string, into a confectioner's jar full of water. When it rests steadily at the bottom of the jar, carefully, with a rod, strike off the glass cover from the bottle. The water and the ammonia-sulphate of copper are in contact, but they do not mix. Gradually it will be observed that the purple solution loses colour, becoming a pale blue. The chemical combination has been overthrown—the ammonia has left the sulphate of copper and diffused itself through the water. In a similar manner, yet more powerful chemical combinations may be broken up.

We are acquainted with other phenomena, in which modified conditions of the force which we have been considering are strikingly shown. Exosmose and endosmose—or, as Mr. Graham terms it, Osmose Force—exhibits phenomena of a peculiar character, yet a cautious examination appears to lead to the conclusion that there is little essential difference between it and the forms of force which have been described. A porous tile, a wall of clay, a piece of animal membrane, dividing two fluids, differing but slightly in their character—say, for example, sugar and water—shall be on one side of the partition, and water only on the other. Porosity immediately begins its work: the solid substance in solution (this mode of expression can scarcely be avoided, but the substance in solution does not exist in the solid state) passes through in one direction while a little of the purer fluid passes through in the other direction. Flowing in and flowing out goes on until all the sugar, or other substance, leaves its own cell and settles itself in the other. By this process numerous chemical decompositions can be effected, as in the cases already cited. In each and all of these phenomena, it is tolerably certain that we are dealing with an obscure, but a most energetic force, possessing more resemblance to gravitation than to any other known power, but distinguished from it by broad lines of difference. In gravitation we discover a power acting, irresistibly, amongst the particles of matter, drawing all to a mathematical centre, while, at the same time, we detect an influence—is it diffusive?—which binds mass to mass in space and regulates the motions of worlds. In the sur-

face force under consideration we find a power acting in perfect independence of gravitation—often in opposition to it; but it is a caved giant, whose power is limited to the cave in which it dwells.

Pursuing a series of investigations, all of them being remarkable examples of experimental induction, and which may be regarded as originating in the more simple phenomena referred to, Mr. Graham was led to the discovery that certain metals not only absorbed some of the gases, and especially Hydrogen, but that they retained those metals, or as the discoverer termed it "*occluded*" * them. When iron or platinum or palladium in a state of tolerable purity—whether in the form of sponge, or aggregated by hammering—is heated, and allowed to cool slowly and completely in a hydrogen atmosphere, those metals are found to have absorbed many times their volume of the gas, and to hold it in a state of "*occulsion*" for any length of time; until, indeed, it is dispelled by heat. It was the discovery of this fact, and the examination of meteoric iron, which led to the remarkable discovery that these meteoric masses must have passed through—and indeed cooled in—an atmosphere of hydrogen gas. Mr. Graham advanced from this point to a knowledge of a new method of charging metals with hydrogen at low temperatures. When a plate of zinc is placed in dilute sulphuric acid, hydrogen gas is liberated from the water by the oxidation of the metal, and it is evolved from the surface of the zinc, but no hydrogen is occluded. Mr. Graham remarks, "a negative result was to be expected from the crystalline structure of zinc." We are disposed to ask why crystalline structure should interfere with this power of retention? If, however, a thin plate of palladium is immersed in the same diluted acid, and brought into metallic contact with the zinc, the hydrogen is transferred to its surface, and the gas is largely absorbed. The charge taken up in an hour by a palladium plate, rather thick, at 12° amounted to 173 times its volume.

"The absorption of hydrogen was still more obvious when the palladium plate was constituted the negative electrode, in acidulated water, to a Bunsen battery of six cells. The evolution of oxygen gas at the positive electrode continuing copious, the effervescence at the negative electrode was entirely suspended for the first twenty seconds, in consequence of the hydrogen being occluded by the palladium. The final absorption amounted to 200 volumes."

The hydrogen enters the palladium and no doubt pervades the whole mass of the metal, but it exhibits no disposition to

* *Occlusion* is a good old English word, signifying to 'shut up,' which had fallen out of use, until Mr. Graham restored it as a scientific term.

leave the metal, and escape into a vacuum, at the temperature of its absorption. Pieces of palladium charged with hydrogen have been sealed up in exhausted glass tubes. After two months the glass has been broken under mercury, and the vacuum found perfect, no hydrogen having vaporised in the cold, but on the application of heat 333 volumes of gas were evolved from the metal. Another experiment was of a very striking character. A hollow palladium cylinder was made the negative electrode in an acid fluid, while the closed cavity of the cylinder was kept exhausted by means of a Sprengel aspirator. No hydrogen whatever passed into the vacuous cavity in several hours, although the gas was no doubt abundantly absorbed by the outer surface of the cylinder, and pervaded the metal throughout.

It appears that when hydrogen is absorbed by the metal palladium, the volatility of the gas may be entirely suppressed; and hydrogen may be largely present in metals without exhibiting any sensible tension at low temperatures. "*Occluded hydrogen is certainly no longer a gas, whatever may be thought of its physical conditions.*"

It has often been maintained on chemical grounds that hydrogen gas—the lightest body in nature—is the vapour of a highly volatile metal. Sir Humphry Davy and others have drawn attention, from time to time, to certain conditions which appeared to connect hydrogen with the metals, and now the results obtained by the Master of the Mint appear to confirm those views. Mr. Graham remarks: "The idea forces itself upon the mind that palladium, with its occluded hydrogen, is simply an alloy of this volatile metal, in which the volatility of the one element is restrained by its union with the other, and which owes its metallic aspect equally to both constituents." The following brief statements of the conditions of palladium—and of palladium charged with hydrogen—will elucidate this point.

It should be stated, in the first place, that palladium in the state of thin films, as thrown down from a solution of the chloride by a voltaic battery, when heated to 100° in hydrogen, and allowed to cool slowly for an hour in the same gas, was found to occlude 982·14 volumes of the hydrogen. This is the largest absorption of hydrogen which has been observed, and certainly it is not a little remarkable to find a dense body, such as the metal palladium is, absorbing and retaining nearly one thousand times its volume of so light a body as hydrogen is. The density of palladium when charged with eight or nine hundred times its volume of hydrogen gas is perceptibly lowered. A palladium wire before exposure measured 609·144 millims (23·982 inches). This wire received a charge of hydrogen amounting to 936 times its volume, and increased in length 9·779 millims (or 0·385

inches); it measuring, when charged, 618·923 millims. The density of the charged wire is reduced from 12·3 to 11·79. The expulsion of hydrogen from the wire, however caused, is attended with an extraordinary contraction of the latter. On expelling the hydrogen by a moderate heat, the wire not only receded to its original length, but fell as much below that zero as it had previously risen above it. That a very remarkable change is produced in the palladium by the absorption of the hydrogen is shown by the manner in which it burns. A wire so charged with hydrogen, if rubbed with the powder of magnesia (to make the flame luminous), burns like a waxed thread when ignited in the flame of a lamp. It has been proved that the tenacity of palladium is altered by the occlusion of hydrogen. The tenacity of palladium wire being 100, the tenacity of palladium and hydrogen was found to be 81·29.

Dr. Faraday determined, by many experiments, that palladium is "feebly but truly magnetic," and he placed this element at the head of what are now called *paramagnetic metals*. The experiments of Mr. Graham show that, with occluded hydrogen, palladium becomes so magnetic that it must be allowed to rise out of the paramagnetic class, and to take place in the strictly magnetic group with iron, nickel, cobalt, chromium, and manganese. Many chemical peculiarities distinguish this compound from ordinary palladium. The conclusions which appear to flow from this enquiry are, that in palladium fully charged with hydrogen there exists a compound of palladium and hydrogen in a proportion which may approach to equal equivalents. The charged palladium is represented by weight as

Palladium . .	1·0020 grm .	99·277
Hydrogen . . .	0·0073 grm .	·723
		100·000

It is in the proportion of one equivalent of palladium to 0·772 equivalent of hydrogen $H=1$, $Pd=106·5$. The evidence is therefore strong that a true alloy is produced, and to this alloy the name of *Hydrogenium* has been given.

In this alloy hydrogen appears to be reduced to the metallic state, and the great problem of the chemist, as it regarded the physical condition of hydrogen, is satisfactorily solved. The magnetic character of this alloy may have its bearing upon the appearance of hydrogenium in meteoric iron, in association with certain other magnetic elements.

The absorption of hydrogen by palladium is a striking fact. That this gas is absorbed by platinum and by iron has also been proved. The occluded hydrogen found in meteorites points to a condition in space, upon which we can only obscurely speculate. Spectrum analysis is teaching us that this

element—hydrogen—forms an important constituent of the nebulous groups and cometary films. The examination of surface forces instructs us that the element which, oxidised, becomes water, and which, in its combinations with carbon, plays so important a part in the animal and vegetable economy, is no less essential as an agent modifying the conditions of the mineral world. From the study of little things—the solution of sugar, the absorption of water by a sponge—we are advanced to the discovery of truths which bear on the mysteries of molecular structure, and on the constitution of worlds in space.

THE STRUCTURE AND AFFINITIES OF THE SEA-SQUIRTS [TUNICATA].

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[PLATE XLVII.]

"Profecto enim a summis molluscis ad infima zoophyta, 'Natura non facit saltum.'"—*Chamisso.*

THOUGH the animals which are the subject of the present article are well known to the naturalist, they are by no means familiar objects to the ordinary sea-side rambler; partly because some members of the order are oceanic, in part for the reason that those which are inhabitants of our coasts are either unattractive in appearance, or, if better-favoured, are concealed by rocks and the fronds of sea-weeds.

Some, however, of our readers, when wandering along the edge of a shore strewn with the litter of a recent storm, "counting the dewy pebbles, fix'd in thought," may perchance have stumbled across a curious object, combining the consistency of leather with the appearance of a lump of dirty ice, to which, maybe, sticks an empty shell-valve, a mass of pebbles, or a root of tangle. This, after being handled, is very probably squeezed, and out shoot two jets of sea-water into the face of the observer.

The creature, not inaptly termed a "sea-squirt," is an Ascidian;* belonging to a class called Molluscoida, from a zoological, rather than an external and obvious, resemblance to the Mollusca—e.g., limpets, whelks, razor-shells, mussels, oysters, cuttle-fish, sea-hares.

The Tunicata, or Ascidioida—that division of the Molluscoida with which we are at present concerned—comprise, besides the sedentary "sea-squirt," some roving oceanic members

* Derived from the Greek ἀσκός, a wine-skin (the "leather-bottel" of the Orientals), to which the animal in question bears no slight resemblance.

Plate XLVII.

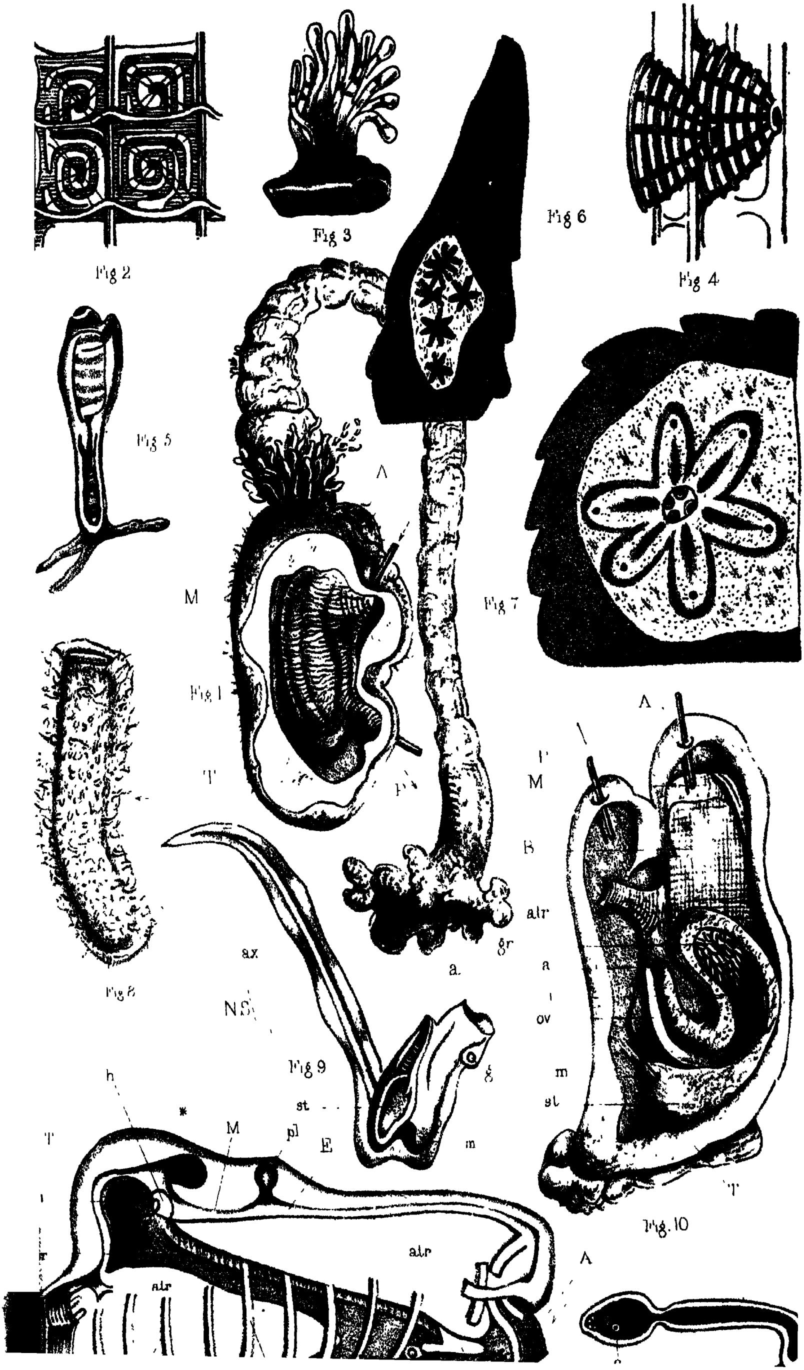
Fig 2
Fig 3
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Fig. 10
A

which have no popular designation, but are known to naturalists as the genera *Salpidæ* and *Pyrosomidæ*.

Before, however, proceeding to survey the almost Protean variations which the Tunicata present, we will examine, somewhat in detail, the structure of a representative, both of the nomad tribes, and of those which have a fixed habitat, the lease of which expires only with life.

To begin with the latter. The outer coating of the Ascidian, which varies in consistence, is termed the "test." * This is pierced by two openings, situated at a varying distance from one another, sometimes occupying the extremity of two necks, which render the creature a caricature of the "Wolff" bottle, known to workers in the laboratory. One of the two orifices (the uppermost, if they be on a different level) admits water (air-laden) and food; the other gives exit to excretions, intestinal and generative, and to water (airless). (Figs. 1 and 10, T.)

A most important point in connection with the test is that it contains cellulose (no less than 60 per cent.), the possession of which substance was once held to be the exclusive privilege of the vegetable world. Its presence, however, is supposed to be due to a *destructive* rather than to a constructive chemical change.

It is significant that the fresh-water polype, or *Hydra*, contains chlorophyll, and this, moreover, not derived from vegetable food, but elaborated in its own tissues. The test is the true homologue of the shell of bivalves—e.g., the river-mussel (*Anodonta Cygnea*).

Beneath the test lie two inner coats—namely, the muscular "inner tunic" (Hancock), which is homologous with the "mantle" of bivalves; and the "lining membrane" ("inner tunic," Huxley). These two tunics are generally closely adherent, except where the viscera and blood-channels intervene. (Figs. 1 and 10, M.)

The mantle and test are usually free (this is very evident in spirit-preserved specimens), except at the two respiratory orifices mentioned above, where they are adherent, and at points where vessels pass to the test, serving as slings or side-stays.

The bag formed by the combined mantle and lining membrane copies in its outline that of the inner surface of the test; and has, moreover, two orifices corresponding with those pierced in the latter.

A little distance within the passage of entrance ("inhalent") into this bag is a circlet of tentacles, pointing downwards and

* From the Latin *testa*, a piece of baked clay, a potsherd, a wine-jar.
"Quo semel est imbuta recens servabit odorem
Testa diu."—*Hor.*

forming the upper margin of a fold of the lining membrane, termed the "anterior collar" (Hancock).

Most of the muscles of the mantle run in a more or less longitudinal direction, interlacing in a manner which reminds us of the arrangement of muscular fibres which Dr. Pettigrew has so clearly demonstrated in the stomach of man and other mammals. Some fibres are disposed in a circular manner round the two orifices, and, as Van der Hoeven says, "Sphincteres veluti efficiunt." (Fig. 1.) They are of the *smooth* variety.

A certain space, termed the "pallial chamber" * or "atrium" † (*atr*, fig. 10), intervenes between the lining of the mantle and a sac or bag, yet remaining to be described—

"Apparet domus intus, et atria longa patescunt."

This "domus intus," which comprises the gill-sac, the digestive tube with its accessory glands, and the organs of reproduction, lies almost free in the pallial chamber. The gill-sac (*br*, fig. 10) which has a texture like that of coarsely-woven gauze, has, at its upper end, a wide mouth, the margin of which is attached to the mantle a little below the "anterior collar." At its lower extremity is a much smaller aperture, the true mouth of the animal. What anatomists would call the "visceral" portion of the lining membrane is closely adherent to the gill-sac, besides being reflected over the heart and other viscera, in the manner of a peritoneum.

Along that side of the body which is farthest from the aperture of exit, the two lateral lobes, into which the gill-sac is supposed to be resolvable, are separated by certain folds of the lining membrane which are converted into a longitudinal rod, termed the "endostyle." These folds diverge above, to become continuous with the lower portion of the anterior collar. On the opposite side of the sac intervenes a similar fold of the lining membrane, the "oral lamina," which is continuous above, after bifurcation, with the anterior collar; and below forms, with the lower extremity of the endostyle, the "posterior cord."

The gill-sac is made up of a number of large transverse blood-channels, crossed by smaller longitudinal ones, which form the margins of narrow elongated windows ("stigmata") fringed with cilia, and often having a very beautiful structural arrangement (figs. 2 and 4). A number of stout longitudinal bars run from one end to the other of the gill-sac, attached only where they cross the transverse vessels. At these points there is situated a ciliated papilla. The water which traverses the sac, after parting with its oxygen to the blood circulating

* From Lat. *pallium*, a mantle.

† *Atrum*, the entrance hall of a Roman house.

through the vascular sieve, passes out through the "stigmata" into the "atrium," and leaves the body of the animal by the exhalent orifice. The circulation in these animals is indeed—to borrow an expressive word from Goethe—a "Zauberfluss," for instead of a definite onward current there is actually a tidal ebb and flow.

The heart is a muscular tube of considerable length, open at either end, but having no valves. It lies in the region of the lower border of the stomach, between the mantle and lining membrane, and is invested with a fold of the latter, in the fashion of a pericardium.

The arrangement of the vessels has been most carefully studied and clearly described by Mr. Hancock, but is somewhat complicated; so that, were there sufficient space here for description, our readers would weary. Suffice it to say that there are two main longitudinal trunks, which eventually terminate at either end of the heart; one of which runs along the endostyle, while the other courses along the opposite side of the gill-sac. These are brought into relation by means of the transverse vessels of the gill-sac, and by a circular channel situated just below the "anterior collar."

Owing to the connection of the main trunks, either immediately or mediately, with certain networks which ramify in the mantle and over the digestive tract, and with vessels which serve the test, the blood which is returned to the heart by either of these channels in its turn, arrives in only a partially aërated condition; that trunk, however, which courses along the endostyle being the carrier of the least pure fluid.

The number of heart-pulses in either direction is not constant, but varies considerably. As regards their duration, Mr. Hancock found that it "required 2¼ minutes to accomplish the beats during a single oscillation."

The digestive system is comparatively simple. The mouth, which is situated at the bottom of the gill-sac, leads almost directly into the stomach, upon the floor of which there is a longitudinal fold, which is continued into the intestine. The tube formed by this latter and the stomach is folded twice upon itself, the concavity of the first loop looking toward the heart (hæmal flexure, Huxley). In the second loop the reproductive organs usually lie. The anus opens into the atrium, in the neighbourhood of the exhalent orifice (fig. 10, *m*, *st*, *i*, and *a*). The food, which is sedimentary, consisting of Diatoms, &c., is not selected by the animal. It is sifted from the water which traverses the gill-sac by ciliary action, accumulated at the "oral lamina," before mentioned, and conducted along this organ, formed into a cord by a mucous secretion, to the mouth.

The liver is a gland made up of delicate branching tubes which

end in rounded extremities. It thinly coats the intestine, and opens by two ducts into the stomach.

Overlying the liver, and burrowed into by the reproductive organs, is a ductless glandular mass, permeated by blood-channels, which may "act," as Mr. Hancock says, "as a sort of packing" (like Paley's spleen ?) "to these organs." Its vesicles may also aid the heart "by their resiliency when the mass is gorged with blood."

The two sexes are combined in one individual. Though separate organs are devoted to the secretion of the male and female elements, they are associated in one mass, reminding us of the so-called "ovo-testis," which occupies the last whorl of the liver in Gasteropods (e.g. snails and slugs). Their ducts, which are distinct, follow the curvature of the last loop of the intestine, and terminate at the atrium, by the side of the anus (*gr* and *ov*, fig. 10). The ova are probably impregnated in the "cloaca"—that portion of the atrium into which the generative ducts and anus open. In each is developed a tadpole-like embryo (fig. 12), which is hatched about thirty hours after fecundation. The fore part of this tadpole—as we may term it—is furnished with three sucker-like projections. By these it attaches itself to some suitable spot before undergoing subsequent changes. A pigment spot may also be seen in the middle line of the back, and a second one laterally (fig. 12 *e*). These were at first supposed to be eyes; but Krohn, from his observations, considers this not proven. They persist for a long time after larval existence, but, after fusing into a single mass, finally disappear. The tail of the larva, after being retracted into the interior of the now attached body, where it is rolled up into a spiral coil, breaks up eventually into a lobular mass, and becomes no longer visible. A cylindrical axis has been lately discovered in the larval tail, resembling in structure the noto chord of the lancelet (*Amphioxus*), the lowest of the fishes. It is significant that the late Professor Goodsir pointed out the likeness between the enormously dilated, ciliated, and perforated pharynx of this very fish and the gill-sac of the Ascidian.

The nerve system is very rudimentary, there being but one ganglion, situated betwixt the inhalent and exhalent orifices, and lying between the mantle and lining membrane. From it radiate a few nerves to the respiratory tubes and mantle, and to the "branchial tubercle," a supposed organ of special sense (taste or smell ?) which lies immediately in front of the upper end of the oral lamina.

We will now pass on to a brief survey of the erratic Tunicata, taking the *Salpidæ* as representatives of this division.

These animals are of especial interest to the naturalist, seeing

that it was in them that Chamisso * discovered a peculiar mode of reproduction, termed by him "alternation of generations," a discovery since verified by the late observations carried on by Huxley on board the "Rattlesnake."

A *Salpa* (fig. 11) is a somewhat irregular, hollow, translucent cylinder, open at both ends, each orifice being furnished with a valve. Though the animal swims "indifferently," says Huxley, "with either end forward, and with either side uppermost," that end where the mouth opens may be considered as anterior, and that side as dorsal where the heart is situated.

There are two tunics, adherent only at the margin of the two orifices. The outer corresponds to the Ascidian test, while the inner is made up of the homologues of the mantle and lining membrane, which are in close contact, except where blood-channels intervene. (Fig. 11, M and T.)

A few bands (five or seven in number) of *striped* muscular tissue run across the inner tunic, transverse to the long axis of the body (*bm. bm*, fig. 11). A band ("hypopharyngeal band," Huxley), composed of two laminæ adherent along their dorsal edge, crosses the body-cavity ("pallial chamber") obliquely from behind forwards and downwards (*br*, fig. 11). This has been called a gill, but "somewhat too exclusively, as there can be little doubt that the whole respiratory cavity performs the branchial function."

A tongue-shaped body, the "languet" ("länglicher Organ," Eschricht), at the base of which lies a ciliated sac, projects into the body-cavity, where its ventral wall is joined by the anterior end of the so-called "gill." It is supposed to subserve the sense of taste. (Fig. 11, *cc*.)

A single ganglion lies just behind the *languet*, to which, as well as to the walls of the body, it sends nerves. To its lower surface is attached a vesicle containing pigment and calcareous bodies, leading to which is a depression in the outer tunic. (Fig. 11, *g*.) This probably corresponds to the auditory organ in those orders of which the snail and river-mussel are representatives.

The digestive tract is very simple, being included in a small knob—the "nucleus"—situated at the hinder end of the body. (Fig. 11, *n*.)

It is connected with the mouth by a furrow running along the ventral aspect of the animal. The intestine is spirally coiled, and has a sac—the stomach—attached to its left side. The anus opens above and to the right side of the mouth. Over the last portion of the intestine is spread a network of trans-

* Better known, no doubt, to most of our readers as the author of "The Shadowless Man" (Peter Schlemihl).

parent tubes, which may perform the function of a liver, or represent a rudimentary absorbent system.

Though the circulatory system consists of "sinuses," i.e., blood-channels without distinct walls, many of these are constant in position; namely, the *dorsal*, enclosing the endostyle; the *ventral*, in which the ganglion lies—*lateral* sinuses connecting the two former—a sinus surrounding the viscera, and a channel which traverses the "gill." These communicate round the œsophagus; above and in front of which lies the heart (fig. 11, *h*)—an imperfectly tubular organ, having walls of *striped* muscular tissue. There is a blood-tide, with intervening pause, as in the Ascidia.

It had long been noticed by naturalists that the *Salpidæ* occurred in two well-marked forms; one, as a solitary specimen; the other consisting of a number of individuals joined together in a chain, which moved through the waters of the ocean in a serpent-like course. These two forms were described as distinct species until Chamisso discovered that they were but phases in the existence of one and the same zoological individual.

It will be advisable to term them, after Huxley, "*Salpa* A," and "*Salpa* B," in order to avoid the use of a theoretical nomenclature.

Though these forms are very similar internally, they differ outwardly in certain points, such as shape, texture of the integument, number of the muscular bands, and length of the endostyle. Encircling the nucleus of a specimen of *Salpa* A, may often be found a chain of embryonic B *Salpæ*, which are attached in pairs to the side of a cylindrical tube which takes origin just in front of the heart, and is an outgrowth from the sinus-system. The cavity of this "gemmiferous tube" communicates with the dorsal sinus of each embryo; and Professor Huxley "has seen one of the large blood-corpuscles of the parent entangled in the heart (which was not more than $\frac{1}{500}$ of an inch long) of a very young fœtus."

Each embryo is attached to its neighbour by means of a communicating channel between their sinus systems. This channel gradually narrows until it becomes a mere pedicle; and, finally, all communication ceasing, the young *Salpa* B is free.

"It is clear, therefore," says Professor Huxley, "that the gemmiferous tube is nothing more than a stolon, containing a diverticulum of the circulating system of the parent, and the whole process of reproduction as it is manifested in Salpa is one of gemmation. *Salpa* B is a bud of *Salpa* A." Before its liberation from the chain, each B *Salpa* generally contains a *solitary* fœtus, attached by a pedicle to the upper and hinder part of the wall of its respiratory cavity. This connection between parent and offspring is, moreover—most wonderful to re-

late—like that of the highest Vertebrata, truly *placental*. The "placenta" * (fig. 11, *pl.*) consists of two sacs; the outer of which, concave and cup-shaped, communicates with the dorsal sinus of the fœtus; while the inner, which is spherical, and received into the concavity of the outer sac, opens into a sinus arising behind the heart of the parent. Each sac is divided internally by an incomplete partition, so that a current sets down one side and up the other. *There is no communication between the sacs*, the flow of blood in each being independent of that in the other. In process of time this bond is snapped asunder, and the offspring is launched into the wide waters as "*Salpa* A."

To sum up, in the words of Professor Huxley, "There is no 'alternation of generation,' if by generation sexual generation be meant; but there is an *alternation of true sexual generation with the altogether distinct process of gemmation*."

Professor Huxley, after clearly pointing out the difference between a *zoological* and *metaphysical* "individual," proposes to term each form of *Salpa*—namely, A and B—a "zoöid;" seeing that these are only *collectively* equivalent to the "individual" of higher animal forms, being in structure but part of an individual, namely, *organs*.†

The male reproductive gland of *Salpa* B surrounds the intestine like a network. Since its stages of development are later than those of the ovary of the same zoöid, it may be inferred that impregnation takes place from without.

In a young A *Salpa* may be seen at the hinder part of the sinus surrounding the viscera a mass of oil-containing cells, termed by Krohn "elæoblast" ‡ (fig. 11*). The function of this organ is unknown; but its occurrence in an animal possessed of a placental circulation suggests an analogy to a "thymus" gland.

The *Salpidæ* are said by Chamisso to be luminous, but no reference is made by Huxley to this point.

Having now described a representative both of the fixed and wandering Tunicates, but small space is left at our command for mention of the varieties of these two groups.

* This structure, which forcibly reminds us of one of the "cotyledons" of the placenta of a cow, "is identical in structure with a single villus contained in a single venous cell of the mammalian placenta, except that in the Salpian placenta the villus belongs to the parent, the cell to the fœtus; the reverse obtaining in the Mammalia."

† The process of generation just detailed is termed by Quatrefages, "Geneagenesis." See chaps. xiii.—xvi. inclusive, of his *Metamorphoses of Man and the Lower Animals*. Translated by Henry Lawson, M.D. London, 1864.

‡ From the Greek ἔλαιον (olive) oil; we suppose.

The Ascidia proper comprise—

α. Those which are isolated, e.g. *Boltenia* and *Phallusia* (figs. 1 and 10)—*Compound* Ascidians.

β. Those connected by "stolons"—trailing prolongations like the "runners" of strawberry-plants—into which blood-channels are continued, e.g. *Clavelina* (fig. 5)—*Social* Ascidians.

γ. Those in which the tests are fused into a common gelatinous mass, in which the individuals are imbedded in groups, frequently star-like, e.g. *Botryllus* (figs. 6, 7)—*Compound* Ascidians.

The oceanic members not yet mentioned are, *Pyrosoma, Doliolum,* and *Appendicularia.* The *Pyrosomata* are eloquently described by Professor Huxley as "miniature pillars of fire gleaming out of the dark sea, with an ever-waning, ever-brightening, soft bluish light, as far as the eye could reach on every side."

To speak more prosaically, each animal consists of a hollow cylinder, closed at one end, open at the other, somewhat like a test-tube (fig. 8). At the open end is a kind of valve. In the walls a number of zoöids are imbedded perpendicular to the axis of the tube, whose anterior orifices look outwards, while the posterior open into the interior of the cylinder.

The cylinder moves by the reaction of forced-out water against its closed extremity.

Reproduction takes place in two ways; both by an asexual budding, and by impregnated ova, each of which gives origin to four aggregated zoöids.

Doliolum, as its name implies, is cask-shaped.* Both ends are open, the hinder being fringed. The gill is represented by two bands ("epi-" and "hypo-pharyngeal" of Huxley, respectively) which are connected by transverse bars.

Appendicularia (fig. 9), a minute animal, is the lowest form of Tunicate. In it the larval tail is persistent, while the gill is entirely absent. There is, however, a "ciliated band" on the ventral surface of the respiratory cavity. *Appendicularia* differs from all other Tunicates in having no reversal of the blood-current, and in possessing individuals of separate sex, of which, however, the male only has at present been discovered.

Professor Huxley divides the Tunicata (*Ascidioida*) into three orders—

1. *Branchialia,* in which the gill-sac is so large that the digestive and generative organs are pushed to one side of it. The *solitary* Ascidians, *Botryllus, Salpa,* and *Pyrosoma,* belong to this order.

2. *Abdominalia,* in which the gill-sac, being comparatively

* Diminutive of Lat. *dolium,* a cask.

small, lies in front of the generative and digestive organs. This order includes *Clavelina* and the *Compound* Ascidians.

3. *Larvalia*, comprising only *Appendicularia*.

A few words on homologies.

1. Between the different members of the Tunicata.—As but a portion of the work of respiration is fulfilled by the so-called "gill" of *Salpa*, so is this organ a homologue of but a portion of the gill-sac of the Ascidian, namely, the "oral lamina."

Two ciliated bands, which in *Salpa* encircle the anterior end of the respiratory cavity, and in *Appendicularia* remain rudimentary, seem to answer to the "anterior collar" of the Ascidian.

The "branchial tubercle" of the latter appears to be homologically, as well as functionally, represented by the "languet" of *Salpa*.

Lastly, the "elæoblast" of Krohn may turn out to be the representative of the erectile structure which coats the digestive tract of the Ascidian.

2. Between the Tunicata and other sub-classes.—Though Professor Huxley declared long ago that "great as are the apparent resemblances between a Lamellibranch and an Ascidian, they all vanish upon close examination," the belief is not yet given up by some anatomists that true comparisons may be made between these two divisions. According to this view, which is adopted by Professor Rolleston, of Oxford, in a forthcoming manual on comparative anatomy, the gill-sac of the Ascidian corresponds to the branchial cavity or to the left gill of the river mussel, and not to a dilated pharynx; while the entrance and exit orifices of the former will respectively answer to the inhalent and exhalent siphons, rudimentary in the river mussel, well developed in the "gaper" (*Mya*).

The anterior end of the Ascidian will be that at which the animal is attached, and the line of the endostyle will indicate its dorsal aspect, while the oral lamina will represent the hæmal region of the river mussel.

The single ganglion of the Tunicata will, finally, answer to the "parieto-splanchnic" ganglion of the Lamellibranch.

The crown of tentacles of the Polyzoa (of which the "sea-mat"—*Flustra*—may be a familiar representative) is supposed to answer to the gill-sac of the Ascidians by some; by others to the fringe within the inhalent orifice, the gill-sac corresponding to the dilated pharynx of the Polyzoa. To others, lastly, these structures do not present any homologies.

The Tunicata were not unknown to ancient naturalists. Aristotle, the father of philosophic zoology, gives a capital account of the Ascidians under the name of τήθυα.*

* See the first half of cap. vi. lib. iv. of his *Historia Animalium*.

The same animals seem, moreover, to have formed a not unimportant item in the "Materia Medica" of the Romans; for Pliny writes:—"Tethea torminibus et inflationibus occurrunt. Inveniuntur hæc in foliis marinis sugentia, fungorum verius generis quam piscium. Eadem et tenesmum dissolvunt renumque vitia." *

The Tunicates well illustrate what Darwin has so aptly termed "The Imperfection of the Geological Record," for no remains which can with certainty be referred to this group—which might be expected, from their lack of a calcareous shell—have yet been discovered in any formation.

EXPLANATION OF PLATE XLVII.†

FIG. 1. *Boltenia* (from the educational series in the Museum of the Royal College of Surgeons). A vertical section has been made through the test, which has internally a cartilaginous appearance. Lying free in the exposed cavity is the body of the animal, invested with the muscular mantle. Glass rods are inserted into the orifices of entrance and exit.

" 2. Portion of gill-sac of *Ascidia Parallelogramma*, highly magnified. After Alder.

" 3. *Clavelina producta*, natural size. After Milne-Edwards.

" 4. Cones of gill-sac of *Molgula arenosa*, seen in profile, highly magnified. After Alder.

" 5. *Clavelina lepadiformis*, natural size. After Milne-Edwards.

" 6. *Botryllus bivittatus*, on a piece of sea-weed. Natural size. After Milne-Edwards.

" 7. The same species, magnified. After Milne-Edwards.

" 8. *Pyrosoma*. From the educational series, Royal College of Surgeons.

" 9. *Appendicularia Flagellum*, highly magnified. After Huxley. The letters N S indicate a scale of the natural size of the animal.

" 10. *Phallusia nigra*, from a Hunterian specimen, Royal College of Surgeons. One side of the test, mantle, and gill-sac has been removed, in order to display the digestive tract and the organs of reproduction *in situ*.

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* *Naturalis Historia*. lib. xxxii. 31.

† Through the courtesy and kindness of Mr. W. H. Flower, F.R.S., Conservator of the Museum of the Royal College of Surgeons, permission was gained from the Museum Committee to make drawings from preparations contained in the Museum of the College.

We are also greatly indebted to Mr. Charles Robertson, Demonstrator of Anatomy at the University Museum, Oxford, for some magnificent specimens of *Ascidia Arachnoidea*, by the aid of which the memory has been refreshed on several important points.

FIG. 11. *Salpa* (*Africana*, Forskahl). A young *solitary* zoöid. After Professor H. Müller.

„ 12. Fully-developed larva (or tadpole) of *Ascidia Ampulloides*. After Van-Beneden.

The same letters indicate corresponding parts in all the figures.

The arrows point in the direction of water-currents.

T.	Test.	*st.*	Stomach.
M.	Mantle.	*pl.*	Placenta.
B.	Gill-sac.	*i.*	Intestine.
E.	Position of Endostyle.	*gr.*	Reproductive gland.
g.	Ganglion.	*ov.*	Oviduct.
m.	Mouth.	*cc.*	Ciliated cavity.
a.	Anus.	A.	Inhalent orifice.
		P.	Exhalent orifice.
br.	Hypopharyngeal band.	*e.*	So-called eye.
atr.	Atrium, or respiratory cavity.	*a.x.*	Axis of "caudal appendage."
**	Elæoblast.	*bm. bm.*	Muscular bands.
n.	Nucleus.	*h.*	Heart.

THE PLANET SATURN IN JULY 1869.

BY RICHARD A. PROCTOR, B.A., F.R.A.S.,
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THERE is no object in the heavens which is so well calculated to excite our admiration as the planet Saturn, when observed with a good telescope. The nebulæ exhibit to us systems which are in reality incomparably more magnificent. The double stars, rightly understood—and especially those binary systems whose periods extend over many hundreds of years—afford stronger evidence of the grand scale on which the universe is created. But the evidence which Saturn affords is more readily appreciated. The mind must be dull, indeed, which does not recognise at once, in the splendid architecture of the Saturnian system, the fashioning power of the great laws which the Creator has set His universe. The beauty of the system, the perfect regularity of the gigantic rings, the delicate varieties of colour which the practised observer can detect both in the planet and its attendant ring-system, and the magnificent scale on which all these features of interest are exhibited, attract and impress the attention; while the singular problems suggested by the stability of the rings, or still more by the slow processes of change to which they appear to be subjected, invite the exercise of the fullest powers of the observer and of the mathematician.

The return of Saturn to our skies is rendered this year more than usually interesting, by the fact that the rings have now attained their full opening; so that it will be possible to renew, under favourable circumstances, that examination of their structure which, on the last occasion of the sort, led to the discovery of the dark ring and other singular features. The planet will not indeed attain a high elevation during the coming months, and therefore the opportunities for the application of high powers will be comparatively few. But there can be little doubt, that the numerous able observers, who now nightly scan the heavens with powerful and well defining tele-

scopes, will avail themselves of every interval of good observing weather to scrutinise the Saturnian system. The spectroscope, too, which has already afforded singular and interesting information respecting the rings, will probably be brought to bear afresh upon the question of their structure. We propose now to consider some of the discoveries which have been recently made respecting Saturn and his system, and to suggest some processes of observation which, if well carried out, might afford valuable information on the subject of the rings.

I shall assume a knowledge on the reader's part of all those features of the Saturnian system which are usually described in treatises on astronomy. Nor shall I enter at any length into the circumstances which have led astronomers to recognise, in the system of rings, the presence of a multitude of discrete particles or minute satellites, revolving for the most part in one plane around the globe of the planet. I must make one or two preliminary remarks on this interesting hypothesis, however, lest some portions of what follows should not seem intelligible to those who may not happen to be familiar with the views now received.

It had been shown, by Laplace, that the stability of the motion of such rings as were supposed to surround Saturn could only be maintained by a considerable over-weighting of one portion of each ring, and an equally remarkable eccentricity of position. Later astronomers, admitting this view as the basis of their inquiry, came to the conclusion that the disturbing action of the satellites might cause a balancing motion in the ring-system, sufficient at least to secure stability, somewhat as the slight motions by which a rod is balanced in an upright position, although these motions are severally opposed to the rod's stability, yet by their united effect give to the rod a comparative fixity of position which the most perfect quiescence of the support could not secure. These views maintained their ground until the discovery of the dark ring, and of the strange fact, that the planet's body could be seen through this formation without apparent distortion. The discovery of this ring led to a renewed examination of the problem; and finally Professor Maxwell of Cambridge proved, by a most convincing process of mathematical demonstration, that no solid ring could by any possibility continue to exist as an attendant upon a planet. Either the ring would crumble into fragments under the influence of the forces to which it would be subjected, and these fragments would continue to revolve as a broken ring round the planet; or the ring would be more completely destroyed, and would be brought to the planet's surface. Hence we are forced to conclude that the rings, though con-

inuous in appearance, consist of flights of minute bodies, each travelling on its own orbit around the planet.*

But although to the mathematician capable of following Professor Maxwell through all the processes of a complicated proof, the demonstration of the satellite theory of the rings may seem complete, there can be no doubt that the more convincing evidence of observation is wanted to bring the fact home to the minds of the general student. Now we cannot hope that the most powerful telescopes which man can construct will suffice to reveal the separate bodies which form the ring. When the ring's edge is turned towards us it appears as an almost evanescent line of light, and doubtless if that line had not length as well as breadth, we could not detect any trace of its existence. Yet there is every reason to believe that the apparent breadth of that fine line of light is many times larger than the apparent diameter of any single satellite belonging to the rings. In this way, then, observation is not likely to help us.

But there is a mode in which evidence might be gathered respecting the conformation of the rings, by any observer who had patience to conduct the requisite series of observations.

If we consider the case of a series of flat rings (whose thickness may be neglected) formed as of old the rings of Saturn were supposed to be, we shall see that the apparent brilliancy of the rings ought to vary with the amount of opening. We do not refer to the total amount of light received from the ring, but to the apparent brilliancy of any point upon the system. When a plain surface is illuminated, the science of optics tells us that the illumination is proportional to the cosine of the angle of incidence. In fact, we know from experience that the higher the sun is above our horizon the greater is the amount of light received on the earth's surface around us. Precisely so would it be with the rings if they had plane surfaces. And further, it is a law of optics that the apparent brilliancy of any point of a luminous object is equal to the real brilliancy at that point, whatever may be the distance of the object, or the angle at which the line of light meets the surface (neglecting always what does not here concern us—the influence of any absorptive medium which may be interposed between us and the object).

Now, this being so, it is very evident that if the rings were

* I know not why this conclusion should be commonly attributed to myself. Nothing, I think, can be clearer than the terms in which while dealing with the subject of the nature of the rings, in chapter v. of my treatise on Saturn, I have assigned to Prof. Maxwell the full credit for a discovery with which I have had absolutely nothing whatever to do, save to admire and describe it.

flat the total amount of light received from them (the ball being supposed removed) would be increased, through *two* causes, as the rings opened. Firstly, the increased apparent size of the luminous surface would have an obvious effect. Owing to this cause the illumination would vary as the sine of the angle at which the line of light from the earth is inclined to the plane of the rings. Secondly, the apparent brilliancy of each point of the ring-system would be increased as the sine of the angle at which the sun's rays are inclined to the plane of the rings. Thus the total amount of light would increase as the product of these two sines, or assuming what is commonly the case, that the earth and sun are almost equally raised above the surface of the rings, the total amount of light received from the rings would vary as the square of either sine.

But if the rings consist of a multitude of discrete satellites, there must result a different state of things. Take a single satellite, and we see at once that so long as the whole of this satellite can be seen we get the same amount of light from it, whatever the elevation of the sun above the mean plane of the rings. And though the problem seems to get somewhat complicated when we consider the case of a multitude of satellites, yet it will be found, on examination, that there is no longer the same variation to be looked for as was shown to exist in the former case, owing to the sun's change of elevation. In fact, we have a case somewhat resembling that of the moon; the illumination of whose disc has been shown by Zöllner not to diminish towards the edges according to the varying inclination of the solar rays to the moon's surface, but rather to increase; while calculation has shown the probable reason to consist in the fact that the moon is not a smooth globe, but covered with hills and mountains, whose sides are inclined at greater or less elevations to the mean level of the lunar surface.

This being so, two means of observation seem available. First, a definite part of the ring's width might be compared with the equatorial bright belt of the planet; the brilliancy of that belt being we may assume constant. This method would probably involve difficulties; but from the success with which Mr. Browning gauged the relative brilliancy of different parts of the disc of Jupiter last spring, I have no reason to doubt that, with suitably prepared and graduated darkening glasses, the comparison might be satisfactorily carried out. Then the change of brilliancy of the particular part of the ring examined, as the system gradually closed, would afford evidence of the nature of that portion of the ring, according to the principles enunciated above. Secondly, a process might be applied to Saturn corresponding to that which Dr. Zöllner recently applied to the planet Mars. By determining the total amount of light

received from Saturn at successive oppositions, and deducting therefrom that portion which calculation (founded on the light received from the planet when the ring disappears) shows to be due to the globe, it would be possible to determine according to what law the ring varies in brilliancy as its amount of opening changes, and thus to determine generally what may be the nature of the ring's surface.

The result of the application of spectroscopic analysis to the rings has been at once interesting and perplexing. The spectrum of the planet's light exhibits certain absorption-lines indicative of the presence of vapour. Now Mr. Huggins has discovered that the same lines are present in the spectrum of the ring's light also; and that, of the two, the latter spectrum exhibits these dark lines somewhat the more distinctly. This result is remarkable. It indicates that the amount of vapour through which the light from the globe has passed before reaching us is less than the amount passed through by the light from the rings. We are accustomed to recognise the probability that the globe of Saturn is surrounded by an atmosphere proportional in extent to the enormous volume of the planet. On the other hand, the small bodies forming the rings if they had atmospheres at all, would have vapourous envelopes so limited in extent, one would suppose—the volume of each of these satellites being so minute—that the most powerful spectroscope should fail to reveal any trace of its existence. Supposing them to resemble our own satellite, but on a much smaller scale, their atmospheres would be a million-fold too small to produce any distinctive dark lines in the spectrum of their light; for though the moon is so much the nearest of all the celestial bodies, its spectrum has no dark lines other than those belonging to it as formed by reflected solar light. When we remember that Saturn, when at his least distance from the earth, is upwards of 820 millions of miles from us, or more than 3,000 times farther from us than the moon is, the visibility of distinctive dark lines in the spectrum of the ring will appear one of the most interesting and remarkable results of spectroscopic research. It would be perplexing in the extreme if we supposed the rings to be continuous bodies; but accepting, as we are bound to do, the theory that they consist of flights of minute satellites, the result becomes one of the most surprising that can well be imagined.

The explanation I would venture to offer of this strange phenomenon will, I fear, appear to many unduly speculative, if even it do not seem opposed to well-known physical laws. In an appendix to my treatise on Saturn, I have maintained the view that the moon has so thoroughly parted with its original internal heat that even the gases once subsisting on its surface have been transformed into the solid form. I was aware when

I so wrote, that at the time of full moon the hemisphere we see (or a part of that hemisphere) is subjected to a heat exceeding that of boiling water. An enormous amount of heat poured in this way upon the surface of a planet would be rendered latent in transmitting but a small portion of the solidified gases into the aërial form, and produce no effects observable to us on earth; just as the full heat of a tropical summer's day poured for hours on the peaks of the Himalayas, produces no change which the inhabitant of the valleys can perceive, on the snowy masses lying there. If this view were just, we should learn to look upon all the satellites throughout the solar system as in a somewhat similar state to that of our own moon; and at first sight the members of the Saturnian rings would appear, on account of their extreme minuteness, to be of all others those in which the cold would be most intense. But then a circumstance comes to be considered which would have an effect the other way. It is a part of the theory of the motions of satellite-rings, that there would be continual collisions among the members. I have shown in full, in chapter v. of my treatise on Saturn, how these collisions would arise and how they would operate upon the figure of the ring-system. There would be a gradual increase of width, chiefly through the approach of the inner edge of the rings towards the planet; and there would also be a tendency to the formation of new rings within those already formed. But the true significance of these changes is this, that the whole system must be continually undergoing a loss of *vis viva*. Every collision involves such a loss, and the increase in the width of the system is in a sense a measure of the amount of loss. But this increase of width, though indicating, does not compensate for, the loss of *vis viva*. There is only one way in which the loss can be compensated, and that way is indicated in a passing manner, in a note at p. 126 of my treatise on Saturn. There must be a continual generation of heat corresponding exactly to the loss of *vis viva*. Now this heat must tend to render the condition of all the satellites of the system very different from that of one of the ordinary attendants upon a planet. For all must partake in the distribution of this heat; because it is absolutely impossible that any single satellite can have an orbit which, even for a few hours, can keep it free from collision with one or more of its fellows. Thus every satellite is kept warm, so to speak, by a process of continual friction, and no such process of refrigeration as I conceive to have taken place upon the moon, can come into operation upon the satellites forming Saturn's rings. Nay, it may well be that the heat of these bodies is very much greater than the mean heat of our earth's surface. For processes of collision fully equal to the generation of such heat might be in

operation without appreciably affecting the apparent width of the ring-system. And certainly the present appearance of the dark ring is such as to encourage the view that sufficiently rapid changes are in progress.

It would follow from these views, that the spectrum of the ring's light would exhibit variations corresponding to the various parts of the ring's breadth. Of course, there are already well-marked gradations of light in the spectrum, because the light is different in different parts of the ring's breadth. But the dark lines I have already spoken of as distinctive of the ring's spectrum, ought to be more distinctly seen in certain parts of the ring on another account. For there can be little doubt that the central parts of each ring are those at which collisions take place most frequently between the satellites; and, therefore, if the cause I have been considering is really in operation, the dark lines ought to be seen best in those parts of the spectrum's width which correspond to the central portions of the rings. The observation might be worth making, though it would be one of great difficulty and delicacy.

Some recent researches by Professor Kirkwood, of Illinois, have supplied an interesting and sound proof of the real structure of the rings. They are particularly interesting to myself, as affording an unexpected proof of a view I had put forward some time since which had seemed to some to be more imaginative than well-founded. In the preface to my treatise on Saturn, I had said that possibly we may yet detect in the Saturnian rings the indications of those processes by which the solar system had reached its present state. Now Professor Kirkwood's researches tend directly to establish such a relation.

He had shown that when the asteroids are arranged in the order of their mean distances certain well-marked gaps are observable, and that these gaps correspond to those mean distances which would give periods commensurable with the period of Jupiter. We know that when a planet has a period very nearly commensurable (according to some simple relation) with the period of a neighbouring planet, the two bodies disturb each other much more effectively than they would if there were no such relation. If one of the planets be much larger than the other, far the larger part of the disturbance falls upon the motions of the smaller planet. Saturn, for example, had long since been noticed as having his motions affected by a very remarkable inequality; and the search for a cause resulted in the discovery that the peculiarity is due to the relation existing between the motions of Saturn and Jupiter, by which two revolutions of the former planet are accomplished in about the same time as five of the latter. The disturbance falls principally on Saturn, as being so much the smaller of the two bodies. And,

as the asteroids are exceedingly minute when compared with Jupiter, it is evident that those members of the system which had periods commensurable with his would be very largely disturbed, and so come to have *another* period. Thus we can understand the fact that there should be no asteroids at those particular mean distances from the sun which correspond to the particular periods in question.

But it is clear that if there were any possibility of doubting the fact that the asteroids form a zone of disconnected bodies, the circumstance established by Professor Kirkwood would prove that fact. If, then, we can trace in the Saturnian ring-system any signs of the action of similar processes, we shall have an independent and perfect proof that the rings are not continuous, but composed of discrete satellites. Now this is precisely what Professor Kirkwood has been able to do. He has shown that a small satellite revolving in the space between the outer and inner rings—that is, travelling around the black division—would have a period commensurable not merely with that of the neighbouring Saturnian satellite, Enceladus, but with those of all the four inner satellites. It remains absolutely certain, therefore, that the ring is composed of bodies moving freely in definite orbits. And, further, those who agree with me in accepting the nebular hypothesis (or a modification of it) as truly representing the mode in which the solar system reached its present condition, will see in the law established by Professor Kirkwood the action of one of the processes which must have been most effective in the formation of our system.

This paper would be incomplete if I did not refer to the information which Mr. Browning, F.R.A.S., the optician, has recently obtained respecting the variety of colour observable in the Saturnian system. I had never been able to recognise any well-marked signs of colour on Saturn with a four-inch achromatic refractor.* But not only has Mr. Browning himself been able to detect a variety of tints with his large reflector, but I have seen a letter from an observer (using a similar but smaller instrument) who refers to the same tints. These tints are thus referred by Mr. Browning to the well-known colours of the paint-box:—

"The rings yellow-ochre, shaded with the same and sepia. The globe yellow-ochre and brown madder, orange and purple, shaded with sepia. The crape-ring, purple madder and sepia. The great division in the rings, sepia. The pole and the narrow belts, situated near to it on the globe, pale cobalt blue.

* It must be remembered that small apertures are more favourable, as a rule, for the exhibition of colour than large ones. In the case of Saturn, perhaps, this rule should rather be, "large apertures and high powers."

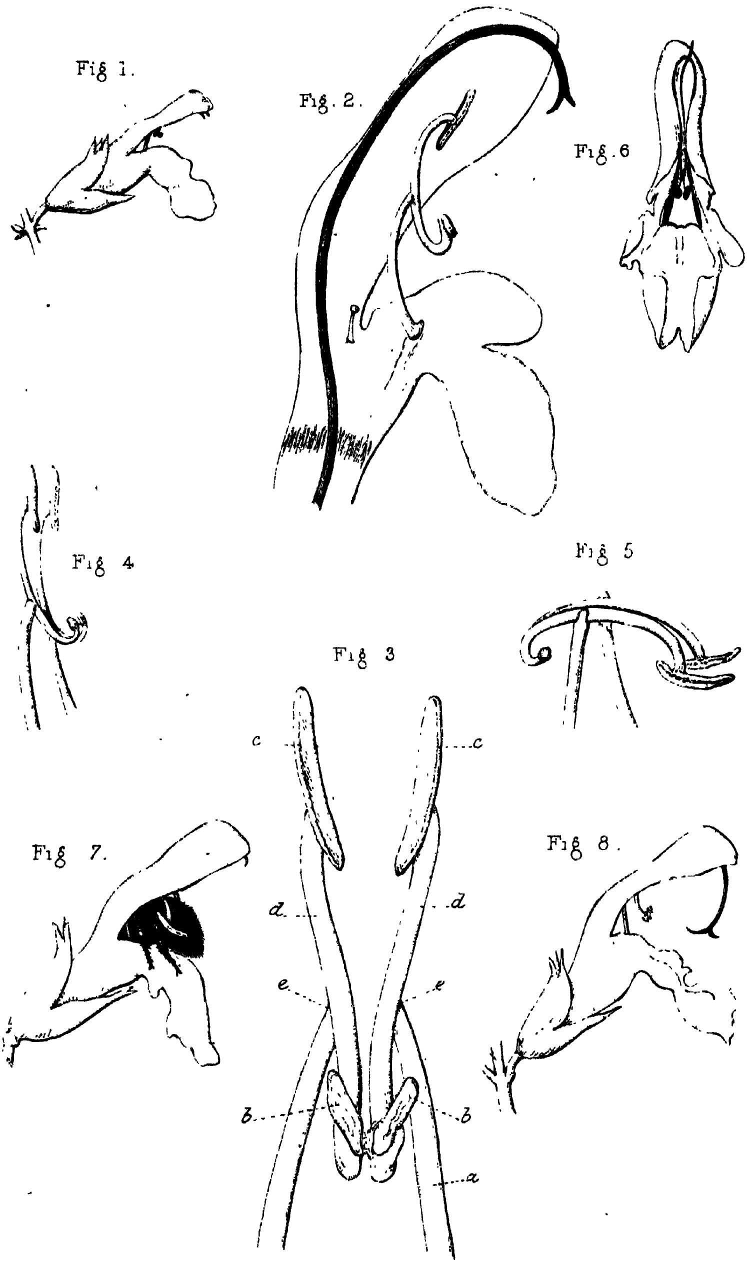
These tints are the nearest I could find to represent those seen on the planet, but there is a muddiness about all terrestrial colours, when compared with the colour of the objects seen in the skies. These colours could not be seen in their brilliancy and purity, *unless we could dip our pencil in a rainbow, and transfer the prismatic tints to our paper.*" *

With reference to these interesting and graphic remarks, it must be pointed out that we might reasonably be disposed to refer phenomena so new and so remarkable to some peculiarity either of the telescope or of the observer's vision, were it not that the observed blueness of the polar regions at once negatives such a supposition. I cannot but think the evidence thus afforded of the adaptability of reflectors to delicate chromatic studies singularly striking and convincing.

It remains to be noticed that the shadow of the planet on the ring will become an interesting subject of observation during July and August. Observers should pay particular attention to the direction of those singular and as yet little understood peculiarities of form which have been exhibited by this shadow. The contrast between the blackness of the shadow and the colour of the so-called black division between the rings, is also well worth noticing. If any doubt could remain respecting the constitution of the rings, no argument could be more effectually used in favour of the satellite theory, than that drawn from the fact that the division between the rings is not vacant, but occupied by some entity or other which supplies a faint but readily detected light. I canot conceive what reasonable theory could be urged in explanation of the peculiarity, save that some minute bodies are travelling within this gap.

* From "The Student" for November 1868.

Plate XLVII



W Ogle.

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The Structure of Salvia

THE FERTILISATION OF SALVIA AND OF SOME OTHER FLOWERS.

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[PLATES XLVIII. AND XLIX.]

MR. DARWIN has, in many places, and notably in his book on orchids, insisted on the dictum, "Nature abhors perpetual self-fertilisation." Even in hermaphrodite organisms there exists, he believes, invariably some contrivance which either entirely prevents self-fertilisation, or at any rate ensures a more or less frequent intercross. In this paper I wish to add some more facts to the many which Mr. Darwin has adduced in support of this proposition. I think I shall be able to show, that in many species of salvia, and in some other plants, there are certain most ingenious contrivances, which hinder or impede self-fertilisation and ensure intercrosses between separate flowers.

The salvia in which I first noted the phenomena which I am going to describe, is a tall handsome plant, which I take to be a cultivated variety of *S. officinalis*. A single flower of the natural size is pictured in fig. 1. The corolla is two or three times as long as the calyx, with a widely open mouth and dilated tube, which admits of the entrance of humble bees. These seem to be especially attracted by this flower, and on my visits to a piece of ground where the plant grew in profusion, I invariably found a large number of them buzzing about the blossoms, settling on the tempting landing-place offered by the central lobe of the lower lip of the corolla, and diving into the recesses of the tube to enjoy the glandular secretion of the nectary at its base. There can, I imagine, be no doubt that the aromatic perfume of the whole plant and the glandular secretion of the fringe in the tube exist in order to promote the visits of bees to the flower.

There are in this salvia, as in others, four stamens, of which, however, the two upper ones are rudimentary. The remaining two have a very peculiar structure. Each consists of a short

stout filament, which is inserted into the mouth of the tube, as represented in fig. 2, and which thence runs backwards, so as to have its upper end completely hidden from view in the hood formed by the upper lip of the corolla. The short filament terminates in a connective which is developed to such an extent as to be actually longer than the filament itself, and at the two opposite ends of the connective are the two anther cells. The portion of the connective uniting the upper anther cell with the filament, is much longer than that portion which unites the filament to the lower cell. The upper anther cell is also itself much larger than the lower one, this latter being, in fact, almost sterile, and furnishing little or sometimes no pollen. It is not, however, so completely transformed into a barren structure as is the case in many other species of salvia, to be spoken of presently. The upper cell, on the other hand, furnishes pollen in great abundance, and allows it to escape by dehiscing in the front longitudinally. The filament is attached to the connective externally by an excessively movable joint, so that a very slight pressure on either anther cell will cause the connective to turn on the filament with what the French would call a "mouvement de bascule." The joint is so strong that you may actually cause the connective to rotate four or five times in complete circles in the same direction on the filament before it is twisted off. The lower or sterile cells of the two anthers are adherent to each other, so that a slight pressure on *one* anther will produce rotation, not only in its own connective, but in both. This description will be more intelligible on looking at fig. 3. In fig. 3 the stamens are represented as seen when looked at in front; in fig. 4 they are seen from the side when at rest; in fig. 5, as seen from the side when the anthers are made to rotate on the filaments.

On looking at the front of the flower, the only parts of the anthers which are visible are the lower cells, with their portion of connective (fig. 6). These stick out into the gaping opening of the tube, projecting like an uvula into the throat. The rest of the anthers is hidden in the upper lip of the corolla, which forms a hood, closed more or less completely in front until the flower begins to wither. The lower anther cells project to such a distance in the mouth of the corolla as to render it quite impossible for a bee to get at the nectary without pushing directly upon their upper surface. No sooner does the bee exercise this pressure than the connective rotates. The upper anther cells emerge from the hooded receptacle in which they are hidden, and are seen to perform a circular movement forwards and downwards, until their dehiscent surfaces are brought into close contact with the back of the bee, one anther cell rubbing it on either side. This movement may be artificially produced by

introducing a pencil into the mouth of the flower, but it is a far more interesting sight to watch it when brought about by the action of the bee. It can be seen with the greatest ease, and no one who has once seen it will doubt that the peculiar form and arrangement of the stamens is not an accidental and indifferent one, but stands in direct connection with the visits of the bee to the nectary; and that the curious modifications in the structure of the whole flower have occurred in order to ensure the adherence of the pollen to the back and sides of the bee (fig. 7).

It will be noticed that the lower anther cells, those against which the head of the bee strikes, are sterile or nearly so. This is an instance of the apparent occasional economy of nature. It would be, as will be seen presently, of little or no use that the bee should have pollen on its head. None, therefore, or little, is produced by the cells against which the head impinges; and the economy thus practised is very probably one of the conditions which favour the abundant production of pollen in the upper anther cells. In these it can be of use, and thus the material saved from the lower cells is expended here to greater advantage.*

It will also be noticed, as a further illustration of the accuracy of adaptation, that the upper portion of connective is very much longer than is the lower. In some other species of salvia this difference of length is much greater even than here. The result of this is, that the bee produces a very considerable rotation in the upper limb of the lever, notwithstanding that the direct motion produced by its own pressure on the lower limb is comparatively slight.

The shape of the corolla is also adapted to facilitate the motion in question or rather to increase its range. It will be noticed in fig. 2 that the tube bulges out just behind the barren anther cells. This allows of a greater displacement of the lower arm of the lever in a backward direction than would be possible were the bulging not present. It is easy to convince oneself, by inspection, that after the bee has struck the lower anther cells with its head, it penetrates still deeper, and that its back forces the cells into this retreat. It thus happens that, though the connective is not nearly so long in this species of salvia as in many others yet that the amount of motion produced in the

* I refer, of course, to the law of balancement of growth, which was thus expressed by Goethe:—"In order to spend on one side, Nature is forced to economise on the other side." The merit of having first propounded this law is claimed for Geoffroy St.-Hilaire, and also for Goethe. It had, however, been most distinctly enunciated by Aristotle. For instance, cf. his treatise "De Partibus Animalium," ii. 9: ἅμα δὲ τὴν αὐτὴν ὑπεροχὴν εἰς πολλοὺς τόπους ἀδυνατεῖ διανέμειν ἡ φύσις, κ.τ.λ.

fertile anther cells is as great as in any, and more than in most.

It will also be noticed that the fertile anther cells are guarded, by the closed hood in which they are concealed, from the wind and rain, so that their precious pollen is not vainly dispersed, but is carefully hoarded until it can be discharged with effect. In none of the many blossoms which I examined did I find the pollen loose in the hood of the corolla; and in no instance in which I was able to watch accurately the egress of a bee from a freshly opened flower did I fail to see the pollen adhering to its back and flanks. When the bee, smeared with pollen, leaves the blossom, the elasticity of the joint at the end of the filament causes the upper anther cells to retire again into their hiding-place, where they lie protected till a second bee visits the flower. This is, at any rate, the rule, but not unfrequently the retreat does not occur. The upper anther cells catch in the narrow opening of the hood, and remain outside exposed. It would thus appear than when the pollen has been shed in part, Nature is less careful in her provision for the protection of organs which are now comparatively useless.

Another point to be noticed in the stamens is the straddling position of the filaments. This is clearly explained by the necessity for a free entrance for the bee, whose passage would otherwise be obstructed. The shortness and firmness of the filaments is such as to give a fixed point for the motion of the connective with its terminal cells. In another salvia, a variety of *sylvestris*, the immobility of the filament, and consequently of the point on which the connective moves, is still further secured by a slight adhesion of the far end of the filament to the edges of the upper lip of the corolla.

The position of the joint which unites the connective to the filament also deserves a passing notice. The joint is lateral, the filament being united to the external surface of the connective, and not touching it behind, so as in no way to interfere with the swing of the latter backwards and forwards (fig. 5).

A more perfect arrangement than that which I have now described, for the transference of the pollen to the body of the bee, cannot, I think, be imagined. Every part of the stamens, even to the minutest details of structure, is so contrived as to ensure this result.

From the stamens I pass on to the consideration of the style. This, as in all labiates, is gynobasic, and from the ovary it runs at the very back of the corolla, being in contact with the posterior surface of the hood, and reaching to its very extremity; that is, to a point considerably beyond that where the upper anther cells lie concealed. As the style follows the curve of the hood, and this is not only closed behind but also slightly in

front at the upper part, the style is necessarily so bent round as to point towards the opening of the corolla tube. When the flower first expands, and for some time afterwards, the tip of the style is seen just projecting from the highest point of the front opening of the hood (fig. 2). The extremity of the style is bifid, and the stigmas occupy the internal surface of the terminal divisions. When the flower is freshly opened these terminal divisions are not separated, but are in close adherence to each other by their inner or stigmatic surfaces; neither are the divisions, nor the style, as a whole, nearly so long as they afterwards become. In fact, the stigmas are not yet ripe, whereas the anthers are. This difference in the period of maturity of anther and stigma, in itself is a security against self-fertilisation, but there are additional safeguards. The style, as already said, is prolonged much beyond the upper anther cells, and thus it is impossible for these cells, when they move in and out of the hood, to strike upon the stigma. This is still further prevented by the anther cells being not only below but *in front* of the stigma, so that their motion occurs without passing by the style at all, and again by the dehiscence of the anther cells being on the side turned away from the style, namely, in front. The bee, in its exit from the flower, does not touch the stigma while it is in this state, as anyone will easily see if he watches a plant for a time; for the bee retires as he entered, along the lower lip, and the width of the opening is too wide for the back of the bee to come into contact with the end of the style. Even were this contact to occur by accident, it would probably be of no effect; for the stigma is at this period immature, and the viscid internal surfaces of the terminal divisions of the style are in contact with each other and not exposed.

The bee therefore flies off with its back smeared with pollen. Should it fly to another blossom in the same condition as that just described, its cargo of pollen will produce no effect: all that will happen will be that an addition will be made to the pollen on its back. But the bee will inevitably soon visit a blossom in a more advanced condition than was that from which its pollen was derived. Here it will find the stigma in a different position. After the blossom has expanded for a time, the style with its terminal divisions increases very considerably in length. These latter also separate from each other, and expose the mature stigmatic surfaces. The style, as it grows, is forced by the hood to lengthen in a curve, and thus the stigmas are brought into such a position that they block up the entrance into the mouth of the corolla, just as the lower anther cells block up its throat (fig. 8). A bee which visits the flower in this condition cannot possibly enter without rubbing its back against the projecting stigmatic surface, so that it cannot fail

to leave some of its pollen adhering to the viscid organ. The stigma does not, as a rule, come so close to the lower lip as to be struck by the bee's head; this passes underneath it, and therefore it would be useless for the bee to carry pollen on its head. The sterility of the lower anther cells thus receives its explanation.

I think I have now shown that every portion of this flower, even to such trifling peculiarities as might have been supposed to be without import, is really so modified as to facilitate fertilisation by the aid of bees, and to ensure intercrossing. I will briefly recapitulate the chief points.

1. *The Corolla.* (*α.*) The lower lip affords a tempting landing-place on its middle lobe, while its side lobes regulate the direction in which the bee settles, and compel it to approach the tube in a direct manner. (*β.*) The deep tube of the corolla compels the bee to dive into it for a certain depth, to get at the nectary, and so ensures the necessary pressure on the projecting anther cells. (*γ.*) The secretion of nectar at the glandular base of the corolla attracts the bee by its taste and odour. (*δ.*) The upper lip forms a close hood, so as to shelter the fertile anther cells, and prevent waste of pollen. The same lip, owing to its being curved and closed behind, compels the style to grow in such a form as eventually to bring its stigma into contact with the pollen-smeared back of the bee. (*ε.*) The corolla bulges behind in such a way as to allow of free motion to the barren anther cells.

2. *The Stamens.* (*α.*) The filaments are short and firm, so as to afford a secure point on which the connective may revolve. This security is increased in one salvia, if not in more, by adherence of the filament to the upper lip of the corolla. (*β.*) The straddling position of the filaments leaves a free entrance for the bee. (*γ.*) The filament is articulated with the connective so as to allow of a larger range of motion. (*δ.*) The arm of the levers on which the bee directly acts is the shorter, so that the fertile cells are made to move considerably by a comparatively slight motion of the bee itself. (*ε.*) The lower anther cells are barren or nearly so, as pollen on the bee's head would be wasted. On the other hand, the upper cells are very fertile, and their dehiscence is on the side which is brought into contact with the bee's body, and which is turned away from the stigma. (*ζ.*) The lower cells project so that the bee must of necessity strike them.

3. *The Style.* (*α.*) The stigma ripens after the anthers. (*β.*) The stigma is so placed as to be protected from the pollen of the same plant. (*γ.*) The style grows in a curve, so as eventually to come in contact with the back of the bee.

I have described this variety of salvia at such length that it

will be sufficient if I give a much shorter account of other forms. Neither will it be worth while to do more than select a few species from the very many I have examined.

Salvia glutinosa.—This salvia, in its general arrangements, has a close resemblance to that which I have just described at length. The most notable differences are these:—The lower anther cells are entirely unproductive of pollen, and, instead of projecting from the hood, lie inside the tube, the opening of which they block up. Neither in glutinosa nor in any of the other salvias to be hereafter described, is there the bulging recess in the hinder part of the corolla which I pointed out in the last species, and which allowed of a greater range of motion backwards in the lower anther cells. To compensate for this, these salvias have a more or less developed bulging out on the opposite side, that is, on the lower surface of the tube. This bulge gives a freer access to the nectary when the anther cells have been pushed back as far as they will go. This bulge is not nearly so marked in glutinosa as in many other species. The stigma in glutinosa, as in most species, matures later than the anthers; still the difference in time is not so great but that blossoms may be found in which there is a mature stigma, and anther cells containing pollen.

This species is fertilised by the large humble bees. The smaller humble bees and the hive bees visit it, but have not a proboscis long enough to reach the nectary. They have, however, learnt to overcome this difficulty. They make a hole in the tube of the corolla just above the nectary, and thus rob the flower of its secretion, without performing the duty which nature intended to attach to the enjoyment. How thoroughly the bees have acquired this treacherous habit, and how perfectly they have learned that their proboscis is too short to get at the nectary in any other way, anyone will see who spends half an hour in watching this plant. The bee makes straight for the hole in the tube, and never makes the slightest attempt to get in at the mouth. At any rate, though I have watched often, I have never seen it do so. Once or twice only I have seen the bee, instead of going to the hole, fix on the hood, and rifle the pollen. The hole in the tube is always made in exactly the same place, and nearly every blossom has one made into it sooner or later. On one occasion I examined a large number of flowers, and found the hole in 90 per cent. of them. This is an interesting example of the occasional imperfection of Nature's arrangements. One is reminded of a trap so faultily constructed that a cunning mouse can manage to carry off the bait, without setting the machinery in motion, by getting at it in some circuitous way. There are other plants, such as the common scarlet-runner, which are treated by bees in a similar way.

I come now to a number of species in which the lower anther cells are still further modified, being transformed into little hollow plates. The concavities of these plates are turned upwards, and by the union of the plates a little boat-shaped receptacle is formed, which more or less completely blocks the opening into the tube. (See figs. 9, 10, 11.) Under this heading come *S. sclarea, pratensis, sylvestris, grandiflora, patens, splendens*, and a vast number of others. The most interesting of them is *S. patens*. This one, therefore, I will describe.

S. patens. This large garden-flower can be easily obtained and examined. It will be found that there is a different mechanism for its fertilisation from that of any other species I have mentioned. The style, when it reaches the lower part of the hood, passes from behind forward between the two anthers, and higher up passes back again between them a second time, and then projects above them from the lip of the corolla. (Fig. 12.) At the points where it passes between the anthers, it is held firmly by them; and thus, when the anthers rotate the style moves with them, coming forwards and retiring back in company with the upper anther cells. These and the stigma retain their relative positions to each other while this motion goes on. (Fig. 13.) Should now a large insect visit the flower and push the lower petaloid anther cells in order to get at the nectary, its back will be struck not only by the polliniferous anther cells, but also a little farther back by the stigma. As the insect passes deeper into the tube, the anthers and stigma will be rubbed along its back in a direction from before backwards, the stigma being always in advance of the anther cells, and therefore not collecting any of the pollen. As the insect retires from the flower the anthers and stigma retreat into the hood. The insect flies off to another flower, and now the motion brings down the stigma on to the pollen-smeared place in its back. It will be noticed that, in this species, the upper division of the stigma is very much larger than the lower, which is in fact almost abortive, whereas in most other species the lower division is the lustier. The possible purport of this is to cause a greater interval between the pollen and the stigma, and thus to render the chances of self-fertilisation smaller. On examining the corolla tube, it will be noticed that there is a curious constriction in its lower part. By this the calibre of the tube is reduced at that point to a very small passage, and this passage is filled up completely by the style which runs through it; so that, in fact, at this point the tube is entirely blocked up. On now examining the inner surface of the tube with a microscope, it will be seen that the part above the constriction is thickly set with glandular hairs, while the part below is entirely devoid of them. It is by these glandular hairs that the fluid which attracts insects is secreted, and if a tube be

opened carefully a drop of nectar will usually be seen just above the constriction. The use of the constriction seems, then, to be, to prevent the nectar from escaping below, and getting out of reach of the insect's proboscis. The glandular hairs are most abundant just above the constriction, and get scantier and smaller higher up. The purpose which is here served by the constriction is in many other species attained by the glandular hairs themselves, which are set so thickly as to form a dense fringe, which only just leaves room for the passage of the style, and with this completely blocks the tube. (See fig. 2.)

I come now to a matter which seems to me of considerable interest, but concerning which I would speak with diffidence. On examining a number of blossoms of *Salvia patens*, I found that there were two kinds. The great majority, in the arrangement of stamens and pistil, accorded with the description I have just given. In a certain number, however, the arrangement was different. In these the style was much shorter than in the others, and only passed once between the anthers, namely, at the lower part of the hood. (Fig. 14.) It thus projected from the hood *below* the fertile anther cells, and not above, as in the majority of blossoms. The consequence of course would be, that when the stigma and the anther cells are brought down on to an insect's back, the stigma would strike at a point nearer to the insect's head than would the anthers. (Fig. 15.) It is plain, that an insect visiting first one form of blossom and then the other would have the same points on its back in contact first with the anther cells of one blossom, and then with the stigma of another. This dimorphism would therefore be a second way of insuring crossing between different flowers. The blossoms with the long style I found very many times more numerous than the blossoms with the short style; and it may therefore be that these latter were only accidental, though tolerably frequent, deformities. It is plain, however, that if such dimorphism be of use to the plant by insuring intercrossing, the plant, when growing wild and subjected to a struggle for existence, might avail itself of this "accidental" occurrence, and that in time the short-styled flowers might come to be equally numerous with the long-styled ones.

The flower is not, as far as I can make out, fertilised in this country by any insect. Growing only in a cultivated condition, it is not subjected to any other struggle for existence than that entailed by the changing fashion and caprice of horticulturists. This, however, has been so severe, that I was unable to obtain last summer from Covent Garden shops any large number of specimens, and thus I am unable to say in what proportion the two forms of blossoms exist.

I will not weary the reader with descriptions of other species. I have examined some thirty, and in all have found some con-

trivance or other to interfere with self-fertilisation and favour intercrossing. The anthers are not always rotatory, but in such case their position and dehiscence are such as to render it impossible for a bee to get at the nectary from the mouth of the tube without carrying off some of the pollen on its body, which it will convey to another flower; while at the same time the position of the stigma, and its different periods of maturity, protect it from the pollen of its brother anthers.

I would now illustrate the facts I have described by the phenomena presented in the fertilisation of some other plants.

If a common mallow, or a hollyhock, be examined soon after it has expanded, the stamens will be seen rising up in the centre, and forming with their united filaments a tube, from the upper end of which the filaments again diverge, each to terminate in an anther cell, loaded with large grains of pollen. The ripe pollen drops in abundance from these anther cells, and may be seen lying at the bottom of the corolla. Here, at the points of junction of the separate petals, will be seen certain glandular bodies, one at each interval, which secrete a fluid which attracts bees and other insects. The fallen pollen will be seen adhering in quantities to this sticky secretion, so that an insect which comes to enjoy the nectar, can scarcely fail to carry off some grains attached to its head or body. At this time no stigma nor style is visible. This lies entirely out of sight in the tube of the filaments, and is, in fact, quite immature. It is only later on, when the pollen has been entirely, or almost* entirely, shed, that the stigmas make their appearance above the tube. When once they have emerged, their growth is rapid, and they soon assume, as they lengthen, such a position that an insect which visits the nectaries must in so doing impinge upon them, in which case it will leave upon them some of the pollen it has brought from a less mature flower.

Intercrossing, then, in these plants is secured by the stamens and stigmas reaching their maturity at different periods. But it is to be noticed, that this is not the case with all the *Malvaceæ*. There are some in which the stigmas are mature and protrude from the tube in the early period when the anthers are still charged with pollen, so that here self-fertilisation may occur with the greatest facility. Now, it is of great interest to note,

* Very frequently the stigmas make their appearance before all the pollen is shed; and in such cases they may get some grains from their brother stamens. But these will not be numerous; probably seldom enough to produce fecundation. For Gärtner has shown, that even thirty grains of mallow pollen are insufficient to fertilise a single seed; but that when forty grains are applied to the stigma, a few seeds of small size may be formed.—Cf. Darwin, "Animals and Plants," ii. 364.

that in these mallows there are no nectaries. The visits of insects are not required by the plant, and so Nature, who, as Aristotle says, *οὐδὲν ποιεῖ μάτην*, economises the bait by which they might be attracted. A more convincing proof of the ultimate end and purpose of nectaries, cannot, I think be adduced.*

Still more striking are the contrivances for ensuring an intercross in the curious *Lopezia racemosa*. If a flower of this plant be examined, it will be seen that the two anterior petals are bent at a right angle, so that their terminal limbs form a convenient landing-place for flies or other insects. These are, moreover, attracted thither by the secretion of two little glands, which are placed on the upper surface of the petals just at the bend. In the centre of the flower rises a strange-looking object, which, on investigation, is found to be formed of two stamens, and a small intervening style. The stamen which is placed towards the glandular petals, has a polliniferous anther, the dehiscence of which faces these petals. The other stamen is transformed into a petaloid organ, and its upper extremity is shaped into a little hood, into which the anther of the first stamen is fitted, so as to be entirely out of sight. Between the two stamens is a style, which is therefore also roofed over by the staminal hood. But when the flower first expands this style is very short, and its end does not nearly reach up into the hood, where the fertile anther is lodged. The style is indeed at this period quite immature, and the terminal stigma not developed, whereas the pollen is already ripe.

If now the front part of the staminal hood be touched ever so lightly, it will be seen to start back, liberating, in so doing, the polliniferous stamen which it had hitherto held prisoner. This, when let go, springs slightly forwards, and by the jerk the pollen is shot out in the direction of the glandular petals. Some of it will be found to lodge on the glands themselves, and to be retained there by the viscid secretion. None can possibly fall on the stigma, for this lies behind the stamen, that is, on the side turned away from the dehiscence of the anther. Even if any accident did convey a little of the pollen to it, it would be of no use, for, as already mentioned, the stigma is at this period quite immature.

Now, when a fly or other such insect lodges on the glandular petals, it can scarcely fail to touch the front part of the hood. The pollen will then be shot out—will strike the fly on some part of its head or body. Here it will lodge, and the fly will

* The fact that nectaries are absent from these *Malvaceæ*, in which the anthers and the stigmas ripen together, was observed by Vaucher, to whom, however, the fact was without significance, as he had no notion of the real use of nectaries.

carry it off to another flower. That the flies do thus act anyone may easily convince himself, if he watch a *Lopezia* for a short time. Sometimes the staminal hood appears to spring back, and to liberate the polliniferous anther without the aid of an insect, a mere current of air sufficing to produce the movement. But in this case the pollen is not necessarily wasted; when emitted, it adheres to the sticky surface of the glands, and an insect which afterwards comes to enjoy the glandular secretions will get many of the grains on its head and proboscis.

The insect then, smeared with pollen, flies off to another flower. If this be in a more advanced condition, the stamens will have withered up and disappeared; but the style, which was in the earlier flower short and immature, will have lengthened and developed at its termination a large viscid stigma, which occupies just that place which in the freshly opened blossom was occupied by the hood. It is plain that the insect which came into contact in the one flower with the hood, will now come in contact with the stigma, and will convey to its viscid surface the pollen grains with which it is smeared.

In *Lopezia*, then, the fecundation follows the same rule as in salvia and in mallows. The more advanced flowers are fertilised by the pollen of the less advanced ones. The same rule applies to the last plant of which I shall say anything, the blue larkspur of our gardens.

The strange irregularity of this flower is utterly unintelligible, excepting on the hypothesis that it is intended to promote intercrossing. On that hypothesis all is perfectly simple.

The two upper petals are transformed into glandular organs, and secrete a sweet fluid for the purpose of attracting bees or other insects. The posterior sepal is moulded into a spurlike cavity, into which this fluid is poured, and in which it is retained. The two lower petals are so shaped and placed as to form a convenient landing-place, on which a bee must light in order to get at the nectary. The same petals also serve as a protection to the stamens and pistil. These they roof over and guard from the rain and wind, and also from the direct contact of insects, which might otherwise disperse the pollen vaguely. It will at once be seen, on examining a flower, that when a bee lights on the landing place, the stamens and pistil lie underneath it out of harm's way. When the flower first expands, the stamens all hang downwards and forwards, and their anthers are not quite mature. Still more immature are the stigmas at this time. Soon after the flower has opened the stamens ripen, one by one, in succession, and each as it ripens turns upwards, changing its position, until the anther is brought to occupy the fissure which exists between the lower part of the two inferior petals; of those two petals, that is, which above

form the landing-place. The anther is now just in the mouth of the opening into the nectary, and a bee cannot get at the sweet fluid without striking against it; in which case it will get smeared with the pollen grains. Some of the pollen will also fall into the glandular cavity, and this also will afterwards adhere to the proboscis of the insect as it sucks up the fluid.

As soon as all the pollen is shed the stamen falls back into its old position, and another stamen takes its place, and so on till all the stamens in succession have gone through the same order of changes. Then, and not till then, the pistil with its stigmas ripens, and as the carpels lengthen the stigmas come to occupy the same position in the interpetalous fissure, as was previously occupied by the successive anthers. A bee in getting at the nectary will now strike upon the stigmas, and if it have—as is probable—pollen grains on its proboscis, will leave these adherent to the viscid surface; and thus, as in the other plant I have described, the more mature blossoms are fertilised by the pollen of the younger ones.

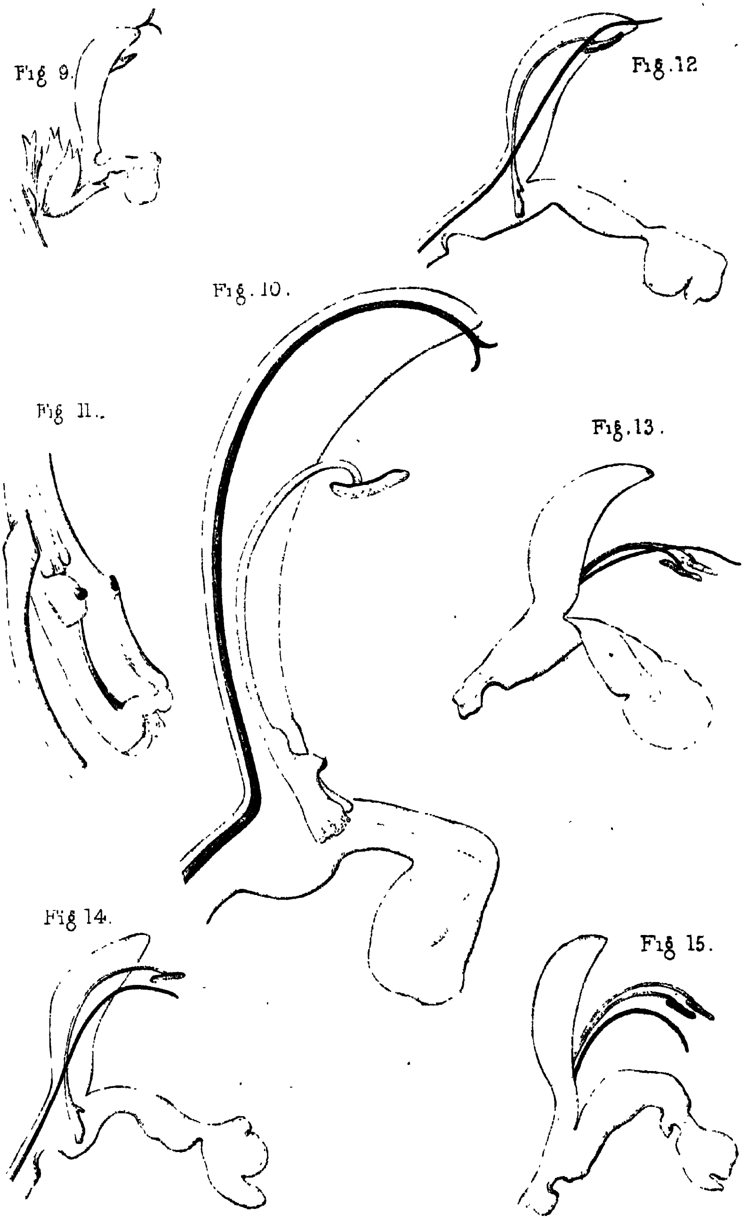
The fertilisation once completed, all the paraphernalia constructed to bring this result about are thrown aside, as no longer of use. The glandular petals, the sepalous receptacle of the fluid, the landing-stage, all fall off, and the plant is spared the cost of their further maintenance.

The preceding paper was written in the summer of 1868. At that time I thought I was the first to have discovered the purport of the strange structure of the stamens in salvia. I learnt later from Mr. Darwin—naturally somewhat to my disappointment—that this was not the case; but that already two years earlier Hildebrand had published an extensive series of observations on salvia, in which the structure was fully explained. On reading Hildebrand's pamphlet, I found not only that this was as Mr. Darwin had told me, but that, even long ago, the main fact had been noted by Sprengel. I have, however, thought it well to publish my own observations for several reasons. In the first place, Hildebrand's paper is so little known apparently, that I can find no allusion to it in any English or French manual of botany. The curious anatomical structure of the stamen is described in all of them, and often is figured, but not a word is said of its physiological significance. A second reason is, that there are numerous minor points, which seem to me of much interest, which have been passed over by Hildebrand.

EXPLANATION OF PLATES.

FIG. 1. S. officinalis, var. grandifloras (?) (natural size).
FIG. 2. Flower in section. Magnified.
FIG. 3. Front view of stamens. Much magnified. *a.* filament. *b.* lower barren anther cell. *c.* upper polliniferous anther cell. *d.* connective; united by a joint to the filament at *e.*
FIG. 4. Stamens seen laterally, and at rest. Magnified.
FIG. 5. Stamens seen laterally when in rotation. Magnified.
FIG. 6. Front view of flower. Magnified.
FIG. 7. Bee visiting nectary and rotating the anthers.
FIG. 8. Flower some time after expansion. Pistil mature. Magnified.
FIG. 9. S. Sclarea. Natural size.
FIG. 10. S. Sclarea in section. Much magnified.
FIG. 11. Boat-shaped receptacle formed by union of lower anther cells in S. Sclarea. Much magnified.
FIG. 12. S. Patens in section. Natural size. Anthers at rest. Usua form.
FIG. 13. S. Patens, lateral view. Anthers rotated as would be the case were an insect to visit nectary. Usual form.
FIG. 14. S. Patens, occasional form in section. Anthers at rest.
FIG. 15. S. Patens, occasional form, lateral view. Anthers rotated.

Plate XLIX.



W. Ogle. W. West, imp.

The Structure of Salvia.

IN ARTICULO MORTIS.

By BENJAMIN W. RICHARDSON, M.D., F.R.S.

I HAVE recently read, in Hammond's Journal of Psychological Science for January of the present year, an essay of more than ordinary interest by Dr. La Roche, of Philadelphia, on the subject of the "Resumption of the Mental Faculties at the Approach of Death." The intention of the learned author of this essay is to show that, in cases whare a sick person has for some hours or days been lying in delirium, he may suddenly become conscious, may speak with wisdom, with power of memory, it may be with pleasure, and yet speak thus as but a presage to the death which quickly follows. The clearest evidence is given of this fact, and the frequency of the occurrence of the phenomenon in the course of the acute fevers endemic in hot climates is forcibly dwelt on. In yellow fever the stage of inflammatory reaction continues, says La Roche, with little or no mitigation from some hours to two or three or more days—generally from sixty to seventy-two hours, and is succeeded by the state of remission (the metoptosis of Mosley or the stadium of Lining) without fever. The pulse loses its excitement, becomes almost natural or slower than in health, or rapid, feeble, and nearly imperceptible; the skin regains its natural temperature, then is colder and colder, and bedewed with cold perspiration; the pain of the head, back, and limbs disappears, or is greatly diminished. The redness and glistening appearances are no longer apparent, but the redness is replaced by a yellow tinge. These signs in the general course of the disease portend approaching death, yet are they accompanied with other signs marvellously singular: the wandering or violent delirium, the seeming sensibility, or deep sleep (coma), subside more or less completely. The patient, who some moments before raved like a maniac, or talked irrationally, or could not be aroused, regains his natural condition of mind; thinks, or endeavours to represent himself; converses rationally on all subjects; is cheerful; sits up in or gets out of bed; walks with a firm step; expresses an appetite for food and relishes what he

takes; and, after enjoying this state of repose for some time, suddenly faints, or is seized with a convulsion, and expires.

Our learned narrator leads us from these facts, which with him are personal experiences, to teach us that all through the literary history of the science of medicine similar facts are recorded. Hippocrates is adduced by him as telling of the symptoms of death in similar cases, and as closing his description with the observation that, "As to the state of the soul every sense becomes clear and pure, the intellect acute and the gnostic powers so prophetic that the patients can prognosticate to themselves in the first place their own departure from life, then what will afterward take place to those present." After this the exquisite picture of the death of Pericles is conjured up from Plutarch, with true artistic skill, to sustain the argument. A plague, perchance a typhus raging and decimating the city of Athens, claims amongst its victims the famous soldier and statesman. The sufferer has in the earlier stages of his malady lucid intervals, and in one of these intervals he wakes up to find round his neck an amulet or charm the women had hung about him; he shows this to one of his friends, to convey that he is very sick indeed to admit of such foolery. Then the disease progressing, the delirium becomes more persistent, and is succeeded by a fit of lethargy, with other indications that death is near. And now, the end close at hand, the friends sitting around, treating him as one absent, speak of the greatness of his merit, reckon up and recount his actions, and the number of his victories; the nine trophies which, as their chief commander and conqueror of their enemies, he has set up for the honour of their city. But, while they thus speak, he has listened and understood, and waking up speaks to them; tells them he wondered they should commend and take notice of things which were as much owing to fortune as to anything else, and had happened to many commanders, while at the same time they should not make mention of that which was the most excellent and greatest thing of all, that no Athenian, through his means, ever wore mourning. And soon after this he dies. Returning from his historical survey, our author, La Roche, comes once more to his own experiences of the phenomena of lucid interval in articulo mortis, after long terms of unconscious existence, and shows by the most convincing demonstration that even in inflammation of the coverings of the brain, associated with change in the brain substance itself, there may be lucidity of thought antecedently to and up to the moment of death.

The nature of the modifications which take place in the diseased organ, and which may account for a resumption of the mental functions after an interruption of some days, is discussed, speculated on well, and still left unsolved. I must not be

tempted to linger on so fertile a theme for my pen, but must proceed to that which, on the present occasion, is the task before me.

The perusal of La Roche's essay has recalled many observations I have made, and many thoughts that have crossed my mind, when, in the exercise of my useful, though often powerless, art, I have been obliged to see, with humiliated sense, the mastery of the last great enemy. Whether a brief description of certain of these observations and thoughts will, reduced to writing, be of service, I cannot predict; but in the unsurpassed and unsurpassable state of general ignorance on the subject, I feel if they do anything they can do nothing but good. They may tend to bring the phenomena of death before the mind of the world, as phenomena belonging strictly to the natural—phenomena which should quicken no mystery, gratify no credulity, inspire no false report of Nature and her works.

THE MIND AND DEATH.

In the first place I would remove, as far as is possible, the idea—offspring of superstition and grand-offspring of fear—that by the strict ordinance of nature death is mentally a painful or cruel process to those who are passing through it. I admit, as an obvious truth told every day to all of us by Nature herself, that in the details of her work she, Nature, is not always kind, not always—according to our sense of the word—beneficent; that in her one and grand intent of evolving an universal perfection there is no such special adaptation for advancement, that the advancement shall come with happiness ever by its side, or without pain or misery, to those who are to be perfected. At the same time in this matter of dying the Supreme Intelligence is to all forms of living thing beneficent. In animals inferior to man and less capable of defence, He has removed further than from man the foreknowledge and dread of death; so that at the *abattoir* animals after animals, seeing their fellows fall, go in turn to their fate without a shudder or a moment of resistant fear.

In regard to human kind the Supreme Wisdom has also confined the direct terror of actual death to or near to the moment of death. We find in poetry and sentiment displays of argument truly about life; about the value of life as individually cast in the man; about the dread of losing life, and the like. We find in *fact* that the poetry is misapplied romance, and the sentiment mistaken effort at philosophy. At a pinch, at desperate and sudden and unexpected conflict with death, most men of strong physical powers and strong will would give all they

have for life; that is to say, all they have that could be regained by living; but beyond this there is not much actual and natural terror of death in man. For advancement towards perfection every individual man instinctively obeys the primary will of nature, and advances towards the object with no fear of death in his view. Thus there is little antecedent pain or mental suffering respecting the act of death; so little, that all the systematised use that is made of the terror to render it a moral subjugator has proved harmless; so little, that when we see in any man an undue fear of death—a fear which makes him brood over the grand event, and talk of it to all he meets, and shrink from it by anticipation, and take refuge from it behind straws—we treat him as an exception of an extreme kind to the rest of the world; politely dub him a hypochondriac, and invariably feel that his friends, who are his best keepers, represent him better than he represents himself.

At the worst, in the natural growth of mind, the period of existence in which the dread of death is developed intensely is a period embracing in the majority of persons the mere third of the term of existence. In the young the appreciation of the nature of the event is an act of learning from what is occurring around, and is an act not acquired quickly; so that, happily, the very young, *in articulo mortis*, have, as a rule, no more dread of death than of sleep. In the adolescent there is such rapid aggregation of force—call it life—that they think of death to the last as to them impossible. In the old, the dread which may have marked a transitional stage from prime strength to first weakness, the terror is allayed by lesser care for that which is, and by that curious mental process so persistent that it seems to proceed from beyond us, of bending the mind to the inevitable so gradually and so slowly that the progress towards the final result becomes endurable and even happy.

THE PHYSICAL DEATH BY NATURE.

If, by the strict ordinance of nature, death is not intended to be cruel or painful to the mind, so, by the same ordinance, it certainly is not intended to be cruel or physically painful to the body. The natural rule, the exceptions to which I will speak of in due time, is here clear enough; and it runs, as plainly as it can be written, that the natural man should know no more concerning his own death than his own birth. Born without the consciousness of suffering, and yet subjected at the time to what in after life would be extreme suffering, he will die, if the perfect law be fulfilled in him, oblivious, in like manner, of all pain, mental or physical. At his entrance into

the world, he sleeps into existence and awakens into knowledge; at his exit from the world, his physical cycle completed, he doses into sleep and sleeps into death.

This purely painless, purely natural physical death, is the true euthanasia, and it is the business equally of the physician and of the priest to lead all men to this death as healthily, as happily, as serenely as can be. In respect to the physician, this is his business all in all; and, in regard to the priest, it is so far his business that, in proportion as his labours help towards the end, they help to the moralisation of the world. For euthanasia, though it be open to every race and every nation to have and to hold, is not to be had by any nation that disobeys the laws on which true health, and its obedient follower true happiness, depend; while, to a nation that should obey the law, death would neither be a burthen nor a sorrow.

Despite all our efforts against her, even as the social state now is, nature will indeed still vindicate herself at times, and show us determinedly how she would, if she could, involve, fold imperceptibly, life in death: how, if the free will, with which she has armed us, often against herself, were brought into time and tune with her, she would give us the beauties and wonders of the universe for our portion, so long as the brain could receive and retain, the mind appreciate, and at last would wean us from the world by the most silent of ways, leading us to euthanasia. The true euthanasia (I have read it through all its stages ten times at the least) is, in its perfection, among the most wonderful of natural phenomena. The faculties of mind which have been intellectual, without pain, or anger, or sorrow, lose their way, retire, rest. Ideas of time and place are gradually lost; ambition ceases; repose is the one thing asked for, and sleep day by day gently and genially wiles away the hours. The wakings are short, painless, careless, happy: awakenings to a busy world; to hear sounds of children at play; to hear, just audibly, gentle voices offering aid and comfort; to talk a little on simple things, and by the merest weariness to be enticed once again into that soothing sleep, which, day by day, with more frequent repetition, overpowers all. At last, the intellectual man reduced to the instinctive, the consummation is desirable; and without pain or struggle, or knowledge of the coming event, the deep sleep that falls so often is the sleep perpetual—euthanasia. This, I repeat, is the death by nature; and when mankind has learned the truth; when, as will be, the time shall come, "that there shall be no more an infant of days, nor an old man who hath not filled his days," the act of death shall be as mercifully accomplished as any operation, which, on the living body steeped in deep oblivion, the modern surgeon painlessly performs.

EXCEPTIONS TO THE NATURAL DEATH.

In the natural order and course of the universe there are admitted, as I have said already, some exceptions from the process of the purely natural death. Unswerving in great designs, and at the same time foreseeing every detail of result, the supreme organising mind has imposed on the living world his storms and tempests and earthquakes and lightnings, and all those great voices and sublime manifestations of his mighty power, which, in the infant days of the world, men saw or heard with servile fear. Thus has he exposed us to natural accidents, but so wisely that to those of the creation who are most exposed he gives a preponderance of number, so that during the forming from the first to the last stage, they shall not suffer ultimate loss by disproportion of mortality. Perchance, too, if we could discover the law, he has provided for such excess of life as shall meet every accident natural and human. Be this as it may, he has provided in respect to death by purely natural causes—causes I mean, coming direct from nature without the intervention of man; that, in the vast majority of such cases, the death, sudden, unexpected, inevitable, shall be painless also. As a rule, all forms of death by violence of nature are deaths from the influences of forces all-powerful. Lightning-stroke, sun-stroke, crash of matter, swift burial in great waters—these are the common acts of nature that kill. To the mind these acts present such grandeur of effect, they strike it with a sublime awe; but the body subjected to their fatal stroke is so killed, it hath not time to know or to feel. When we experience any sensation of pleasure or of pain, we have in truth to pass through three acts, each distinct and in succession. We have to receive the impression, and it has to be transmitted to the organ of the mind; here it has to be fixed or registered; lastly, the mind has to become aware that the impression is registered, which last act is in truth the conscious act. But for all these acts the element of time is required, and although the time seems to be almost inappreciable, it may be sufficient. Thus with respect to lightning-stroke, if it strike the body to kill, it accomplishes its destruction so swiftly, the impression conveyed to the body is not registered, and therefore is not known or felt; the veritable death, the unconsciousness of existence, is the first and the last fact of the impression inflicted on the stricken organism. For illustration of this truth I have recently seen—in experiments on the discharge of the Leyden battery at the Polytechnic (the jars being placed in what is called cascade) —animals struck so suddenly to death that they retained, in

death, the position of their last natural act of life. The same has been observed in the human subject after extreme violence of nature, as after lightning-stroke, and for evidence that there is truly no consciousness, in such examples we have another and decisive line of proof.

It sometimes happens that the shock of nature, though sufficient to suspend the consciousness and reduce to the lowest degree the physical powers, does still not kill outright, and that after some lapse of time the mechanical disturbance of the animal organic material ceases; that the molecules fall back into their natural form to reconstitute the natural fabric, and that with the gradual restoration of organic structure there is return of normal function and what is called recovery from simulated death. In time the organ of the mind, also restored, the old imagery of the past returns, and down to the moment preceding the accident the details registered and recognised are capable of recall, or in other words are remembered. But there the memory ceases; of the swift act that disturbed the matter of the body—not with sufficient force to overcome the attraction of cohesion which holds the parts together, in organic series, not with sufficient force to disorganise, but with sufficient force temporarily to modify the organic form required for function—no recollection remains. In a word the conditions requisite for the production of an impression are at once destroyed by the vehemence of the impression.

I have taken this effect of lightning-stroke as the most ready and complete illustration of the truth, that what would seem at first a violent and painful death from a purely natural cause is absolutely a painless death. But the illustration may be extended further--may be extended to all the forms of natural violent death. In cases of temporary suspension of life from sunstroke and from severe mechanical injuries, the same phenomena have been observed. The facts of the injury have not been recorded; there has been no period of conscious recognition of them; there has been no recogniton of that act of consciousness which we call pain. Lastly, to those instances where the suspension of life has followed from what would seem the much slower process of sudden burial, removal from atmospheric air, as in drowning, the rule extends. In two examples of which I am able to speak from personal observation, and in which there was restoration after insensibility, produced by sudden immersion in water, the consciousness of all that occurred from and after the immersion was entirely lost. The same experience has been confirmed by, I think, I may say, all observers.

Thus of Nature it may be safely reported, without entering into longer detail, that when in the course of her determined,

and, as it might seem, unrelenting action, she cannot except even men in their prime from death, she destroys so mightily that the sense of death is forbidden.

THE PHYSICAL DEATH BY MAN.

The spirit bestowed on man, freewill combined with the power to know and to do, to invent, and to imitate nature, places him sometimes in a position to avoid, without presumption, the true accidents of nature. The diversion of the lightning flash so that it shall not injure is a case, among a thousand, in proof of this fact. But this same spirit—this freewill, this super-essential force which acts through matter, and may be wrestled with and conquered by ordinary physical force, and yet defies interpretation—has power also to be destructive, which power it exerts, though with diminishing intensity as it advances towards perfection of knowledge, with the effect of producing far more misery than nature; nay, with the effect of thwarting nature in designs which, if carried out, would lead to the happines, and the good of all. Thus, the totality of death at this moment is so lifted out of the order of nature by the spirit of freewill, that the world practically is a chamber of suicides. By want, by luxury, by pleasure, by care, by strife, by sloth, by labour, by indolence, by courage, by cowardice, by lust, by unnatural chastity, by ambition, by debasement, by generosity, by avarice, by pride, by servility, by love, by hate, and by all the hundred opposed and opposing passions in their excess, we die; I mean we kill. To these causes of death we add and mass up physical evils which, except in the case of fighting armies, destroy even more than the passions; evils which pass from the individual to the multitude, and in shape of vile pestilences sweep away, as by selection, the strongest, the faintest, the youngest of the race.

Yet it happens in this totality of death, in this suicidal destruction, that death as an act is again not, on the whole, cruel or painful. In all the pestilences, and they include a large proportion of the fatal causes, the brain of the stricken usually loses its function long before dissolution, and to the sufferer the last act is a restless sleep. In these forms of disease, when there occurs that strange return to consciousness of which I spoke at the opening of this paper, there is no pain. Those who forebode their deaths are not wretched, and others, the greater part have imparted to them the hope of life, so that they converse as if nothing were amiss, and express that except for a sense of weakness they were well. In cases again of violent death from human causes, from great forces after the order of nature, from crush in collision of railway, crush in battle, the life this moment all action the next all rest, is extinguished without the

consciousness of pain. In lingering death, in death from that disease which piles up our mortality, in consumption, painful as it is, terrible even from day to day to witness, not to say bear, the action of death, though it may be physically hard, is not usually cruel. Striking the young in whom the hope of life and belief in life is strong, consumption has for its victims those who accredit not its power, who live to their final hour in happy plannings of the future and die in the dream.

In the lingering and painful diseases of later life, in diseases we consider yet as hopeless, in diseases where the patient foreknows the end—take cancer or broken heart as examples—death is to the sufferer not often an enemy, but a courted friend. The afflicted here, in case upon case, counts the hour of the release, assured and assuring that "death is better than a bitter life, and everlasting rest than continual sickness; that good things poured on a mouth that is shut are as messes of meat set upon a grave."

I could extend this argument greatly by recalling those *in articulo mortis* whose reason has gone astray; I could, by explaining the phenomena of death in instances where the nervous function is primarily destroyed, strengthen the argument; but the effort is unnecessary. In the end, did I proceed to the end of the chapter of diseases, I should have only those, unhappily but few, who realise pain and cruelty in death from maintaining to the last full mental power in the midst of physical dissolution, or those who, "having peace in their possession," "whose ways are prosperous in all things," and who can "take meat," are forced, in the loss and abandonment of selfish luxury, to give up all and die.

CONCLUSIONS.

I have based this essay on long and careful and truthful observation of the phenomena of death. I have written it for three distinct objects.

1. To declare that Nature, which is to us the visible manifestation of the Supreme Intelligence, is beneficent in the infliction of the act of death; that thwarted in her ways, she is still beneficent, and that she may be trusted by her children.

2. To declare the great law and intention of Nature, that in death there should be no suffering whatever.

3. To declare to men, that whatever there is in death of pain, of terror to the dying; of terror, of unsubdued sorrow to the living, is made pain, made terror, made sorrow; and that to attempt the removal of these is the noblest and holiest task the spirit of man can set itself to carry out and to perfect. It is to give euthanasia to the individual, millenium to the world.

REVIEWS.

PROFESSOR HUXLEY ON CLASSIFICATION.*

IN the year 1864 Professor Huxley brought out a volume on *Comparative Anatomy*, which he then said he hoped to make the first of a series. It included the subjects of Classification and the Construction of the Skull. This work, owing to the author's time having been absorbed by original investigations, has not been followed up, and naturalists cannot but regret the circumstance. The first part, however, of the volume contained matter which was of importance not only to the professional comparative anatomist, but to the student of general natural history, since it laid down Professor Huxley's views as to the principles and scheme of animal classification. The book very soon got out of print, and Professor Huxley thought it advisable to re-issue with some additions the portion of it which was devoted to classification. The volume now before us is the consequence, and we think that all Zoology students will thank the author for reproducing it in its present fórm.

We need not tell those who know anything of Professor Huxley's writings that this book is condensed without losing either force or interest, and that it has been prepared with the utmost care and contains nothing in the shape of dogmatism. In stating his opinions as to the systematic arrangement of animals, the author shows a preference for the division into classes, which he considers to be better defined than any of the other zoological landmarks. Instead, therefore, of definitively grouping animals under four or five distinct sub-kingdoms, he treats of classes from the lowest to the highest. The reader must not expect to find that Professor Huxley has removed all the stumbling-blocks from his way. There are groups of animals whose characters and development are as yet so insufficiently known that it is impossible to determine their affinities satisfactorily. These the author does not place definitively under any division. He may rank them provisionally in a certain position, but he very decidedly declares his doubts, when he has any, as to the ultimate justification of this particular mode of arrangement. The group Scolecida illustrates this fully. Under this title the author places the wheel-animalcules, the Flukes, Tape-worms, Thread-worms, Turbellaria, Gordiacea, and Acanthocephala. But contrasting this class with that of the sea-urchins, he says: "Nothing can be more definite, it appears to me, than the class Echinodermata, the leading characteristics of which have

* "An Introduction to the Classification of Animals." By Thomas Henry Huxley, LL.D., F.R.S. London: Churchill, 1869.

been just enumerated; but it is a very difficult matter to say whether the seven groups, some of considerable extent, which are massed under the present head are rightly associated into one class, or should be divided into several."

It must not be supposed from what we have said that Professor Huxley confines his remarks to the relations and distinctions of the classes. His first observations are devoted to these, but he subsequently goes very fully into the grouping of the classes into sub-kingdoms, and their division into orders. His opinions on the subject of sub-kingdoms are so different from those given in the old text-books that we may briefly advert to them. He does not assert arbitrarily that the animal world should be divided in such and such a manner, but he states fully, and yet with remarkable conciseness, the characters which lead to conclusions on one side or the other, and then modestly expresses the opinion which he himself forms. In this way he explains his reasons for splitting up the Articulata into the sub-kingdoms ANNULOSA and ANNULOIDA, the latter containing the Scolecida and Echinoderms: and the Mollusca into MOLLUSCA and MOLLUSCOIDA, the latter embracing the *Ascidioida*, *Polyzoa*, and Brachiopoda. The Cœlenterata he allows to remain nearly as they were established by Frey and Leuckart. But he very considerably modifies the old group PROTOZOA. Professor Huxley thinks that the Infusoria, which show some relationship to the Turbellaria, present characters which separate them from the sponges in a very marked degree: he therefore proposes that they should stand apart as a sub-kingdom. And finally he allows the *Spongida*, *Radiolaria*, *Rhizopoda*, and *Gregarinida* to stand together under the old term Protozoa. The sub-kingdoms into which he groups the animal world would therefore be—arranging them in Professor Huxley's fashion—as follows:—

	Vertebrata	
Mollusca		Annulosa
Molluscoida		Annuloida
Cœlenterata		Infusoria
	Protozoa.	

The author makes no assertion as to the equivalency of these groups. His object has been rather to show in what way existing knowledge justifies us in arranging the animal classes, than to lay down a constant and permanent system. In one thing we thoroughly agree with him, and that is in believing that the old sub-kingdom Radiata is "effectually abolished." Yet it is strange in how many lecture-theatres the old Cuvierian classification still flaunts in diagrammatic form on the walls, and how many teachers, in defiance of the intelligence of their pupils, cling to the barbarous *omnium gatherum* it expresses. Professor Huxley has done much to bring about its effectual abolition, and we think that the excellent volume before us places it for ever *hors de combat*, by inflicting on it the *coup de grâce* of a keen power of logical argument and an impartial observation of established fact.

THE MALAYAN ARCHIPELAGO.*

WE never remember to have taken up a book which gave us more pleasure, nor to have finished reading one with more regret than this of Mr. Wallace's. Books of travel are generally wearily prolonged land-logs, with details of unimportant incidents and tedious dialogues. Of quite another stamp is this one. Mr. Wallace has been for eight years minutely exploring one of the most unknown, most distant, and yet most interesting portions of the world, and he has written us a romance, which is, nevertheless, plain matter of fact, of its natural history. If we had only space to give a number of extracts from the work, we should be able to do the author some little justice; as it is, we can barely give the rudest outline of one of the most fascinating, and withal important, contributions to physical and biological knowledge which has for some years, at least, been published. The author—who we may mention brought home from the Malayan Archipelago nearly 126,000 specimens—has of course given very graphic accounts of the general features of the myriad of islands through which he travelled, of the natives and their habits, of the colonists and their labours, and so forth. These descriptions make up the great bulk of two handsomely illustrated volumes. But it is not to them we would refer especially, but to the very admirable manner in which Mr. Wallace, uniting the philosopher to the observer, has generalised on the facts presented to him during his researches. It is unhappily too much the case that travellers think they have nothing more to do than shoot a multitude of birds, and collect a quantity of insects, and then send them home and describe them. It is from this impression that writers of books of travel produce such dry and useless volumes. What Mr. Wallace has done, however, will render his work not less significant as a contribution to physical geography than it is attractive as a well written record of a remarkable exploration. The joint originator of the Darwinian theory, has examined both the human and the animal productions of the wonderful group of islands he visited, and his study of them has led him to a conclusion of the highest interest to naturalists and geologists. He has established a distinction of origin and association between the component parts of the Archipelago. Without the good map which accompanies the volumes, we could not explain the direction of the line of division which Mr. Wallace lays down, but we may state it generally.

From a series of carefully taken soundings, Mr. Wallace, following up Mr. Earl's enquiries, has shown that the large islands on the Asiatic side are separated from Asia by a very shallow ocean; he has found that, similarly, New Guinea and its group are separated from Australia by a corresponding shallow sea; but he has seen also that these two halves as it were of the Archipelago are separated from each other by comparatively deep water. From this circumstance, and from a comparison of the natural products, and from a study of the resemblances between the fauna of Asia and the north-western Malayan Islands, and of the Australian fauna and

* "The Malayan Archipelago, the land of the Orang-utan and the Bird of Paradise: a Narrative of Travel; with Studies of Man and Nature." By A. R. Wallace. 2 vols. Macmillan, 1869.

that of the south-eastern islands, he, we think, satisfactorily establishes the proposition that the Austro-Malayan division belongs to the now diminished but originally vast continent of Polynesia, while the Indo-Malayan section is a detached portion of the continent of Asia. The same line of demarcation does not, Mr. Wallace admits, apply to the lower animals and man, but the human line, so to speak, so closely corresponds to that for the animals, that the division, says the author, "is on the whole almost as well-defined and strongly contrasted as in the corresponding Zoological division of the Archipelago into the Indo-Malayan and Austro-Malayan region."

The appendix to Mr. Wallace's work contains a short but useful account of the measurements of the Malayan cranium, and a still more useful list of a hundred and seventeen words as they are found in thirty-three different languages of the Malay Archipelago. In conclusion, we would say of this work, that it is a book worthy to be placed between Lyell's *Principles* and Darwin's *Origin of Species*, for it is an application of the principles laid down in these two standards of English biological philosophy.

THE BRITISH ZOOPHYTES.*

OF the numerous general treatises on natural history subjects which have of late years issued from the press, this one of the Rev. Thomas Hincks is unquestionably the most comprehensive and interesting as it is certain to be the most popular. And when we use the term popular, we mean that the work is one which everyone connected with natural history pursuits must possess—the student must have the book for the purposes of reference, and the amateur will make it his companion to the sea-shore. It is a singular fact, but it unquestionably is a fact, that there is hardly a group in the whole animal kingdom so thoroughly well understood as that of the Hydroid Zoophytes, and yet, till a few years ago, when Professors Huxley and Allman and Mr. Hincks devoted themselves to its investigation, it was a class concerning which our knowledge was represented by "a rude and undigested mass" of statements, which were certainly not in half the cases facts. Now, the morphology of this body of Cœlenterates is so well known that the class may almost be said to be best understood in the whole animal kingdom.

In two handsome volumes, Mr. Hincks has given us a general introduction to the biology of the Hydrozoa, a minute account of all the British species, and a series of illustrations covering about seventy 8vo. plates, and embracing about 300 carefully drawn figures. Altogether the treatise is an exhaustive one; it embraces everything that is known as to the general natural history of the class, and it contains elaborate descriptions of the zoological characters, distribution, habits, and habitat, of every known British species of Hydroid zoophyte. The opening chapter on the general natural history gives an excellent sketch of the peculiar relationship which exists between the polyp-stalk and medusid or gonozoid, and the development of

* "A History of the British Zoophytes." By Thomas Hincks, B.A. 2 vols. London: Van Voorst, 1869.

the planula is very clearly stated, abundant notes accompanying this part of the work, and supplying references to all those sources from which the reader may seek further details. Then follows the plan of tabular arrangement employed in diagnosis. This is an analytical key on the dichotomous method—aut Cæsar aut nullus—which has been found so useful in the identification of species; the primary division of the groups being, however, into two sections, *Athecata*, in which there is a polypary but there are no true calycles, and *Thecaphora*, in which true calycles are present. Those who are already slightly familiar with the Hydrozoa will be glad to find that Mr. Hincks's terminology, while it accords in all essential particulars with that adopted by Professor Huxley, in his "Oceanic Hydrozoa," is nevertheless a briefer one. Indeed it consists of about twenty terms in all, and these are very tersely defined by the author. The chapter on the principles involved in the classification of these organisms is a very careful criticism of the views of other writers, and an avowal of the author's own opinions. Here, Mr. Hincks, accepting Professor Greene's expression of Professor Huxley's method, objects to this, and gives very distinct reasons for so doing, and it is curious to observe that the method of classification really adopted now by Professor Huxley, is that, or very nearly that, which Mr. Hincks proposes. Indeed, the reader who will take up Professor Huxley's work on classification, and compare it with Mr. Hincks's suggestion, will find that in great measure the ideas of the latter have been carried out in anticipation. The three orders of Hydrozoa adopted by the two naturalists may be thus compared tabularly:—

HYDROZOA.

Order { Hydroida, Siphonophora, Discophora.—HINCKS.
Hydrophora, Siphonophora, Discophora.—HUXLEY.

We have one word to say in concluding our notice of this beautiful work, and that refers to the plates. Two editions of the work have been issued simultaneously: in one, the plates have all the fidelity and artistic excellence which was to have been expected from the conjoint labours of Mr. Hincks and Mr. Tuffen West; in the other, a cheaper edition, the plates have been printed by what is known as "transfer," hence the illustrations do injustice to the artist. Motives of economy on the part of the publisher, we presume, are to blame for this, but we should imagine it was not done with the consent of the author. Nevertheless, the illustrations are effective and truthful, and the whole book is really above praise.

VEGETABLE TERATOLOGY.*

JUST as animal teratology affords us a clue in many difficult questions of morphology, so does vegetable teratology afford a key to the laws of the homologies of plants. Or at least so it ought to do. Dr. Masters thinks

* "Vegetable Teratology: an Account of the principal deviation from the usual construction of Plants." By Maxwell T. Masters, M.D., F.L.S. Published for the Ray Society by R. Hardwicke, 1869.

that its importance in this particular can hardly be overrated, or else he would not have given us so large a volume as that the Ray Society has just issued. But we are disposed to join issue with him in this proposition, in so far as the word teratology is applied to the study merely of the characters of monster forms. We are disposed to think—and in doing so we merely follow Wolff, whom Dr. Masters so much admires—that the whole solution of problems in vegetable morphology is to be sought in the careful study of development. If the processes of evolution be watched in abnormal as well as normal structures, doubtless much light will be thrown on the comparative anatomy of plants. But till this is done we despair of any useful results. The book before us is a most comprehensive accumulation of teratological facts, well arranged, but,—and we hope Dr. Masters will excuse our expressing an opinion somewhat strongly on the point,—the question of the development of monstrosities has not been at all sufficiently dealt with by our author, and for this reason we think his otherwise most valuable labours lose much of their importance.

As old students of the Schleiden School, we confess our disappointment at finding how summarily the author disposes of the relation of axial to foliar parts in the development of plants, for—we may be behind the age in thinking so—we do imagine that there is more in this distinction, as a secondary step in evolution, than Dr. Masters seems willing to admit. Still the work before us is an able treatise, remarkably well written and amply illustrated, and must for many years be considered as the book of reference *par excellence.*

FOR DARWIN.*

SOME of the shallow "dinner-table" savants who summarily condemn Mr. Darwin's theory of Natural Selection as being opposed to reason, should be induced to take up this book of Müller's and just look at it. We do not suppose they would understand it, but a glance at it might convince them of their utter incapacity to form a judgment on a subject so vast, and concerning which such an amount of intricate testimony has been advanced. In the work before us a well-known and distinguished naturalist takes up a portion of one class of the whole animal kingdom—Crustacea—and gives us the fruit of a number of patient and painstaking observations on structure and development. His object in commencing his researches was to put Mr. Darwin's views to an extremely severe test. He carried out his intention, and he shows that under the Darwinian explanation all difficulties vanished, and that without it it was quite impossible to understand the relation of certain forms to others. Perhaps the most complex and confusing pursuit in the whole range of zoology is the study of the development of Crustacea, it presents us with so many apparent irregularities and so much complexity. But Herr Müller has given us a minute account of the evolution of nearly all

* "Facts and Arguments for Darwin." By Fritz Müller, with Additions by the Author. Translated from the German by W. S. Dallas, F.L.S. London: John Murray, 1869.

the types of Crustacea, with an observation of minute detail and a dovetailing of little points of evidence worthy of Mr. Darwin himself. He has shown how the law of natural selection is the only one which makes chaos order. The book is illustrated by nearly seventy excellent woodcuts intercalated with the text. The translation is exceedingly clear, and Mr. Dallas must be congratulated by the Darwinians for reproducing so thoroughly able a defence of their principles.

RELIQUÆ AQUITANICÆ.*

THIS splendid work, which is still in progress, continues to be of the highest interest to the student of prehistoric Archæology. It is most luxuriously "got up," and the illustrations in quarto, on toned paper, and in the best style of French lithography, cannot be surpassed. The first of the two parts on our table treats on the fauna of Cro-Magnon, and includes a minute account of the skulls and bones. The plates contain figures of a number of flint implements, of some remarkable mortar-stones, and a beautiful folio drawing of a peculiar perforated weapon made from an antler, and whose use is certainly problematical. The second part contains the description of the Cro-Magnon skulls and bones, supplying numerous careful measurements. Of its five plates three include figures of flint weapons, and two are exceedingly pretty landscapes illustrating the *Roc de Tayac* and the *Château des Eyzies*. This monograph will be completed in about twenty parts, so that it is now nearly half finished. When bound, it will be the most elaborate archæological memoir ever published.

HOW TO WORK IN THE LABORATORY.†

WE quite agree with Professor Bloxam when he says that it often happens that students are kept so long at the examination of the tests for individual elements, that they either tire of the subject, or else fail to recognise the properties of these elements when converted into salts. Such a system, says the author, though teaching the student to discover, for example, that a given salt contains potassium and nitric acid, fails often to instruct him that these constitute saltpetre, and does not acquaint him with the appearance and other properties of saltpetre, by observing which he may be sure that his analysis is correct. This is only too true; and it often happens, as its consequence, that the wrong acid and bases are united in the imagination of the young chemist, and thus very absurd conclusions arrived

* "Reliquæ Aquitanicæ, Contributions to the Archæology and Palæontology of Périgord." By E. Lartet and H. Christy. Edited by T. Rupert Jones. London: Baillière, Parts 8 and 9, April and May, 1869.

† "Laboratory Teaching; or, Progressive Exercises in Practical Chemistry." By C. L. Bloxam, Professor of Practical Chemistry in King's College. London: Churchill, 1869.

at. To the student who is placed under a skilled teacher, this book of Professor Bloxam's will not offer many advantages. But to the amateur who has just fitted up his own laboratory, or to the student who has not the benefit of a teacher of experience, it will prove an invaluable companion. The author's twenty-three years' practice as a demonstrator of Practical Chemistry, has taught him many devices which are of great service to those who have not all sorts of apparatus at their hands. One of the first things a student in the laboratory should learn, is how to be able to make shifts, and this Mr. Bloxam's work teaches him to do thoroughly and effectually.

BRITISH CONCHOLOGY.*

WE have had occasion from time to time to offer our favourable opinion of the different volumes of this work as they issued from the press, and it is now our pleasurable task to notice the last and concluding part in the book now before us. In this, the fifth volume, Mr. Jeffreys carries on his systematic account of British Molluscs, from the naked Mollusca to the end of the Gasteropoda, the Pteropoda and Cephalopoda. There is little to be said of the work that we have not expressed before. The descriptions are very full, and the synonymy, habitat, and distribution are very fairly stated. The illustrations are numerous—in this volume extending to more than a hundred plates; but we cannot say much for their quality. They have a horrible degree of flatness, which gives one the idea that the shell has, while preserving its outline, been "squashed" into one plane by some ingenious process; in some instances this is carried to a degree which renders the figure useless for any purpose save as a terrible warning to natural history artists. The Supplement contains the epitome of a number of facts and notes recorded by the author during the course of publication of the work. The index is a full and well-arranged one, and the hints on collecting are practical and useful. If it were not for the plates, the work would be one of the most convenient and portable handbooks in our language.

HALF-HOURS WITH THE STARS.†

HERE are twelve maps accompanied by explanatory letterpress, and so arranged that any one—be he or she ever so ignorant of astronomy—may study the constellations on any night in the year. As the author says, the beginner in astronomy usually purchases a set of ordinary star maps, for-

* "British Conchology." An Account of the Mollusca which now inhabit the British Isles and the surrounding Seas. Vol. V. Marine Shells, by J. Gwyn Jeffreys, F.R.S. London: John Van Voorst, 1869.

* "Half-hours with the Stars." A plain and easy Guide to the Knowledge of the Constellations. True for every year. By R. A. Proctor, B.A., F.R.A.S., etc. London: Hardwicke, 1869.

getting that the appearance of the sky is constantly shifting, and though such maps show the relation of the several constellations to each other, they by no means show the position of the stars on any particular night. Mr. Proctor may exclaim with Molière, *Nous avons changé tout cela.* He has constructed his maps for every night in the year, and by the employment of ordinary expressions instead of the astronomical ones to indicate the position of the constellations, he has managed to make star-gazing not only a simple, but a most satisfactory pursuit. We remember, when we were students, working out the stars with Lardner's books; but what a luxury such a beautiful series as those of Mr. Proctor's would have been to us. We commend these maps to the notice not only of intending students of the heavens, but to every one; for every educated person ought to be familiar with the constellations. Mr. Proctor has done a great deal already to popularize astronomy by his writings, as he has also achieved much by his original investigations to advance our knowledge of the heavenly bodies; but this last work, elementary as it may seem, gives him his greatest victory, by enabling him to surpass himself.

CHEMICAL CHANGES OF CARBON.*

MR. CROOKES has in this volume reprinted Dr. Odling's excellent lectures delivered to a juvenile auditory at the Royal Institution. Did he do well to reprint them? We think not: and for this reason, that in their present shape they do an injustice to one of the most accomplished and eloquent chemists of the present age. The lectures were given to a number of young people, and the general propositions laid down were enforced by abundant experiment, and by the adoption of a colloquial style of expression, which, of course, involved the employment of short sentences and not unfrequent repetition. Now experiment cannot be reproduced in the printing press, and reiteration is hardly pardonable in a book; and yet Mr. Crookes has published these lectures as they were given—with the repetitions and without the experiments. We ourselves have read the lectures with the greatest interest and pleasure, and have been surprised at the way in which Dr. Odling got over the great difficulty of explaining abstract principles to young people. But we have heard others condemn the book, and we can understand that this condemnation is owing to the circumstances above referred to. On the whole we are disposed to think that the book will prove of great service, but we cannot help thinking that it is rather unfair on the part of some of our "critical" brethren to blame Dr. Odling for the style of composition. As oral lectures they were excellent.

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* "A Course of Six Lectures on the Chemical Changes of Carbon." By W. Odling, M.B., F.R.S. Reprinted from the *Chemical News*; with notes by W. Crookes, F.R.S. London, Longmans, 1869.

GEOLOGICAL CHIPS.*

THERE is not much in these essays that has not appeared in a hundred different forms before. To some writers a few facts are like the bits of glass in a kaleidoscope. They place them together to-day to make one book, and then—shaking up the kaleidoscope—they put them together in another fashion to-morrow, and thus they make another book, and so on. We are rather opposed to this sort of thing, and we find it very prevalent among a few individuals, who have a general knowledge of some branch of science, a keen perception of the gullibility of the public, and a certain power of sketchy writing. We could name on our fingers all those who indulge in this species of manufacture at the present moment, and we are sorry to think that Dr. Page is gradually getting into their orbit. We hope not, for his sake; for once a scientific man falls within an attraction of that kind, it is indeed *facilis descensus*, but very difficult to regain his former position. There is only one chapter in this book which at all deserves any notice, and this, which is entitled, "A Forgotten Chapter," is not by the author. It is a quotation from Verstegan's "Restitution" and is full of interest, since it shows us how much was known of geology in the year of grace 1605. The other "chips" are mere shavings, and we can only hope that Dr. Page will employ his literary "plane" to better purpose in future.

WHAT IS MATTER? †

THE author of this work puts the old never-satisfactorily-answered question What is matter? and, so far as we can gather from his statements, his reply is, that what is called matter is simply force. The case is one which—so far as any evidence yet urged upon it—is absolutely impossible to be decided upon. The testimony supplied is, of course, only the evidence of the senses. In other words, we are cognisant of phenomena. Force and matter are both terms which refer to an abstract substratum which is only a metaphysical entity. We admit the phenomenon, and some of us explain it by saying it is matter operated on by force; others, that it is simply force acting on force; whilst a third says it is matter exhibiting its properties. If we must have an abstract something, let it be force or matter; it is impossible to conceive of both. The author of the book is a wordy writer, with some historical knowledge of his subject, but who is apparently ignorant of practical science, and who makes the serious blunder of resting a reliable mathematical argument on questionable scientific fact.

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* "Chips and Chapters for Amateur and Young Geologists." By David Page, LL.D. Edinburgh: Blackwood, 1869.

† "What is Matter?" By An Inner Templar. London: Wyman & Sons. 1869.

He should remember how Hopkins's mathematical reasonings, as to the solidity of the earth, have been demolished lately by M. Delaunay, not because they were unsound as reasonings, but because the data turn out to have been inaccurate. We would ask an Inner Templar not to waste his time in speculation, but to turn to practical science and do good work.

THE ORIGIN OF THE SEASONS.*

MR. MOSSMAN is an ingenious compiler, but we have a very poor opinion of his capacity as a thinker. In the present work he has clipped with discriminating scissors from the works of Lyell and Croll, and has produced a sort of general treatise on Physical Geography, in which he attempts to explain the variations in climate which different parts of the earth have experienced in Geological epochs; by supposing that the internal forces had modified the earth's form, and thus from certain astronomical reasons, that the tropics had expanded. We have, we must confess, a "lively horror" of philosophers of this stamp, men who quietly settle all the great problems of the time, in a few moments, with the aid of a rule and pair of compasses, and we fear that Mr. Mossman is one of our *bêtes noires*. How far Mr. Mossman's tropics must have extended will be evident to those who read Dr. Oswald Heer's account of the fossil plants of Greenland. Argument is useless in dealing with writers of this class, who condescendingly smile at the speculations of Lyell as being at least pardonable.

The Analysis of Sound and Colour. By John Denis Macdonald, M.D., F.R.S. London: Longmans, 1869. That sound and colour are analogous is hardly a new idea. Nor does the author put forward the idea as a novelty. He, however, urges many arguments in support of their analogy, and illustrates his views with some excellent diagrams.

The House I Live in. Edited by T. C. Girtin, surgeon. New edition, Longmans, 1869. We never read such unmitigated rubbish as this in the whole course of our lives. It abounds in inaccuracies, is written in an awkward vulgar style, and is altogether so discreditable to medical science that we are surprised to see it published by the eminent firm who have put their name on its title-page.

The Laws of Vital Force. By E. Haughton, A.B., M.D. London: Churchill, 1869. The author writes on what he calls Physiodynamic Therapeutics: we have no idea what they are. The reader must not confound Dr. E. Haughton with Professor Haughton, of Trinity College, Dublin. The latter is a most distinguished physiologist.

* "The Origin of the Seasons considered from a Geological Point of View." By S. Mossman. Edinburgh: Blackwood. 1869.

Iron and Steel. By Knut Styffe. Translated from the Swedish by C. P. Sandberg. London: John Murray, 1869. To those who are engaged in the study of the relation between the minute chemical constitution and the physical properties of iron and steel, we commend this volume. It is prefaced by Dr. Percy, and it contains some very valuable records of experiments by the author on the influence of phosphorus in cast iron and steel.

The Birds of Sherwood Forest. By W. J. Sterland. London: Reeve and Co., 1869. This is in great measure a reprint of some papers which appeared a couple of years ago in the *Field.* It contains matter which will interest the general local ornithologist, but it can hardly be called a scientific work. The author shows himself to be a patient and shrewd observer of nature.

SCIENTIFIC SUMMARY.

ASTRONOMY.

M. *FAYE and Mr. Stone on the Transit of Venus in* 1769.—At the Séance de l'Académie des Sciences, January 4, 1869, M. Faye read a paper which practically involved the assertion that Mr. Stone's re-discussion of the observations of the transit of Venus in 1769 was of little value, as having been anticipated by M. Powalky's treatment of the same subject. M. Powalky, it will be remembered, determined the solar parallax to be 8″·832, from a re-discussion of the transit of Venus, based upon more accurate determinations of the longitudes of the stations at which the several observations were made. But it was objected to Powalky's work that he rejected many observations at the more important stations for reasons which do not appear to be founded on any legitimate principles, and that besides employing very few durations, those he actually employed are represented in so imperfect a manner in the residuals that very little weight can be attached to the result. It is to the hopeless task of giving importance to the results of Powalky's labours, that M. Faye has set himself. We may, however, congratulate ourselves that he has done so, as Mr. Stone has been led, in the defence of his case, to give a very able exposition of the rules which should guide the mathematician in treating observations of a transit. In connection with the coming transits these rules are of the utmost importance. They are laid down as follows by Mr. Stone :—

1. There were two phenomena of internal contact which were observed in 1769: the so-called real internal contact, and the apparent internal contact. These phenomena were, in the transit of 1769, separated roughly by about 16s.

2. An observation of an apparent contact is not to be looked upon as an observation of a real contact, and *vice versâ.*

3. In any legitimately conducted investigation, the use of an apparent contact for a real contact, or *vice versâ,* must lead to an erroneous value of solar parallax to the extent which an arbitrary change of about 16s. in the incongruous observation would affect the final result.

4. If observations have to be rejected because of their incompatibility with the general run of the discussion, then every such rejection enormously increases the presumption against the truth of the investigation which requires such rejection.

5. The absolute necessity of rejecting one *good* observation would, in

itself, be conclusive evidence against the truth of the deduced value or the logic of the method applied.

It will be observed that although these rules refer specially to the transit of 1769, they are applicable, with but slight alteration, as rules for the guidance of astronomers in dealing with the observations made upon the coming transits. The last two are laws which those who deal with observations on any subject whatever should hold in constant remembrance.

In applying these rules to M. Powalky's case Mr. Stone proves irresistibly that little value can be attached to results founded on a mode of treatment so irregular as that which M. Powalky has applied to the transit of the last century. After adducing a number of instances in which rules 3, 4, and 5 are broken through, he remarks, "we knew, before M. Powalky's paper appeared, that by adopting different data different results could be obtained. What we did not know was any cause for these discrepancies. The selection of the material had been based upon no intelligible principle, and no one had been able to reconcile the whole of the durations." It is the especial property of Mr. Stone's treatment of the subject that *every* observation of durations is represented, that one constant principle is used throughout, and that the truth of this principle is not founded merely upon Mr. Stone's opinion, but upon the way in which at every step of the work it is confirmed by results.

The Transit of Venus in 1874.—Mr. Proctor states that the places at which the ingress and egress of Venus will be most affected by a parallax during the transit of 1874 are situated as follows :—

	Lat.	Long.
(i.) The place at which first internal contact is most accelerated lies in . .	39° 45′ N.	143° 23′ W.
(ii.) The place at which first internal contact is most retarded lies in . . .	44° 27′ S.	26° 27′ E.
(iii.) The place at which last internal contact is most accelerated lies in . .	64° 47′ S.	114° 37′ W.
(iv.) The place at which last internal contact is most retarded lies in . . .	62° 5′ N.	48° 22′ E.

These places are separated from those which the Astronomer Royal had obtained (by considering passages of Venus's centre in place of internal contacts), by 314·0, 920·2, 764·5, and 208·7 miles respectively.

M. Puiseux, Mr. Proctor, and the Astronomer Royal on the coming Transits.—The views which have hitherto been accepted respecting the treatment of the approaching transits by the method of durations, and which we quoted in our last summary, must, it would seem, be modified. M. Puiseux and Mr. Proctor, having calculated the circumstances of the coming transits with reference to this method, have come to the conclusion, that so far from failing totally in the case of the transit of 1874, it may be applied with great advantage. Mr. Proctor even asserts that it is better than the method founded on differences of absolute time in the occurrence of ingress or egress as seen from widely separated stations. In a note on the subject, Mr. Airy expresses the opinion that M. Puiseux's researches fail to exhibit the method of duration as superior to the method of absolute time differences; but he admits that the former method is one which it is desirable

to apply to the transit of 1874. Mr. Proctor's figures are appreciably different from those of M. Puiseux (who, like the Astronomer Royal, has dealt with the passages of Venus's centre in place of internal contact), and they present the method of durations in a more favourable light than do those which M. Puiseux has obtained. It remains to be seen, however, whether the difficulties of the Antarctic voyages which, as in 1882, would have to be undertaken to render the method of duration fully available, will deter our travellers and men of science from undertaking a task the satisfactory completion of which would be so advantageous to the cause of astronomical science. If it be true, as Mr. Proctor states, that the transit of 1874, when treated by the method of durations, will give absolutely the best means of determining the sun's distance available before the twenty-first century, we need scarcely fear that this country will leave the fulfilment of the task to other nations. Any spot in the triangular space between Kerguelen Land, Crozet Land, and Enderby Land, would satisfy the requisite conditions for a southern station, as also would Sabrina Land, Adelie Land, and Victoria Land. But if an expedition could reach Enderby Land itself, so early as December 8, the observation made there would be the best of all. The northern station should be near Nertchinsk or Tsitsikar, in Siberia.

Mr. Proctor deprecates the sending of expeditions to the neighbourhood of Victoria Land in 1882, as he asserts that there are no stations there at which the sun will have an elevation of 10° both at ingress and egress; and Mr. Stone has expressed the opinion that observations made at a less elevation than this will be practically valueless.

Doubtless these matters will be made the subject of fresh inquiry as the transits approach. It would be a misfortune if any misapprehension of the circumstances of the transit should lead either to the loss of favourable opportunities for observation, or to the dispatch of expeditions, preparatory or otherwise, which would eventually be found to have been misdirected.

Solar Activity.—During the last few months there have been some remarkable evidences of activity in the solar photosphere. We are approaching the epoch of maximum disturbance, and already the formation of large spots, single or clustering, indicates that we may look, during the actual period of the maximum, for manifestations of activity at least equal to those which have been exhibited on former occasions. At a recent meeting of the Royal Astronomical Society two enormous spots were described and pictured, one of them by Mr. Bidder, the other by Mr. Browning. The discussion which ensued led to the consideration of the granules whose nature and appearance have been so often dealt with of late years. Mr. Huggins pointed out that it is only in the neighbourhood of the spots that those irregularities of form are to be noticed which have led to the comparison of the granules to willow-leaves, straws, and so on.

A cluster of spots measured by Mr. Browning on March 7, was found to have a length of 97,700 miles, and a breadth of 27,130 miles. The direction of its length was as nearly as possible parallel to the solar equator.

Winnecke's Short-period Comet.—This comet was re-discovered on April 19 by Winnecke himself, at Karlsruhe. It presented an appearance closely resembling that which it had when first discovered in 1858; large, round,

and faint, with slight signs of nuclear aggregation. No important observations have been made upon it.

New type of Star-spectrum.—Father Secchi announces the discovery of a fourth type of spectrum, which is presented by certain red stars. With some slight differences, this spectrum exhibits a close relation to that yielded by the flame of carbonic oxide.

Auroræ Boreales.—An account of their recognised association with solar action, and the coincidence of their occurrence with the recent disturbed state of the solar photosphere, the auroral displays of the months of April and May last, may worthily claim a place in a summary of astronomical events. A singular feature was noticed in connection with the aurora which was visible on April 15 over the greater part of North America. Around the planet Mars there appeared a vacant space beyond which was a sort of "glory" surrounding the planet, and having radial bars extending to the horizon. The moon appeared like the head of a gigantic comet, the tail being composed of auroral streamers. During the continuance of the display telegraphic communication was affected to a remarkable extent, a circumstance which is now a recognized concomitant of auroras.

The Voyage of the "Jean Bart."—M. Faye has suggested the astronomical subjects which should be principally considered by those who will take part in the six months' voyage of circumnavigation which is about to be undertaken in this vessel. He suggests that observations should be made of the Zodiacal Light in those regions where it shines more brilliantly than in our own latitudes. He points out that it would be advantageous if its contour, the portion of its axis, and other details of its manifestation, could be studied. Attention should be given also to those displays of shooting-stars which correspond to radiant points situated beyond the "circle of perpetual apparition" for our climate. The southern constellations ought to be observed; and something might also be done to furnish useful information for the astronomers who will take part in observing the transit of Venus in 1874.

An Improved Method of Mounting Finders.—The bad adjustment of a finder is a constant trouble to the observer. Professor Piazzi Smyth wrote some time since to Mr. Browning "that he thought some better plan for mounting and adjusting finders was much required." Acting on this hint, Mr. Browning has devised a new and simple mode of mounting these auxiliary telescopes. The common plan is to have the finder placed in the centre of two rings somewhat larger than itself, and adjusted by means of three screws working through each ring, and pressing on bands which serve to strengthen the finder. The great objection to this plan is the complexity of adjustments depending on six screws. Almost equally objectionable is the plan of having a moveable "stop" carrying the cross-wires. Mr. Browning's plan is easily understood and worked. If we consider that the axis of the finder is to be parallel to that of the telescope, we shall see that two things are required. First, the two axes must be in one plane; secondly, they must be in the same direction in that plane. By Mr. Browning's arrangement each of these requisites is adjusted for separately, by the simple movement of two screws placed opposite each other, one pair of screws at one end of the finder giving the requisite motion of that end at right angles

to a plane passing through the axis of the telescope and the axis the finder should have, the other giving to the other end the requisite motion, directly from or towards the axis of the telescope.

The Planets.—The planet Saturn will be very favourably situated for observation during the next quarter. The ring is now nearly open to its utmost extent, and thus the prospect of interesting observations of the dark rings, and of the divisions between the rings, is favourable. It is to be noticed, however, that the planet is now in what may be termed the winter region of the zodiac, and attains but a small elevation above the horizon when on the meridian. Mars is gradually departing from our skies, and has already become a much more difficult object for observation than he was a few months ago. Towards the end of the quarter Jupiter will be visible late at night. Venus will be an evening star.

A New Theory of the Universe.—Mr. Proctor has recently put forward a new theory respecting the arrangement of the stars and nebulæ. Instead of looking upon the nebulæ as for the most part external galaxies of stars, he considers that they belong to our own sidereal system. He discusses the reasons which have been commonly urged for dissociating the nebulæ from our system, and shows that these reasons afford singular evidence in favour of a direct association. He looks upon the stellar system as being far more irregular in its disposition than has been hitherto supposed, and instead of regarding it as approaching in general to the shape of a cloven disc, he regards it as composed of an almost infinite multiplicity of streams, branches, and clusters; here scattered dispersedly, there more or less aggregated; at one place interlacing, elsewhere "bristling upwards from the general level" (to use Sir John Herschel's expression). The Magellanic clouds he looks upon as simply globular aggregations of the sidereal and nebular components which are elsewhere found apart, but which everywhere form but one scheme.

According to these views we see few, if any, external universes, though our belief in the existence of multitudes of these is in no way affected. On the other hand, our conceptions of the scale on which our own galaxy is constructed, of the grandeur of its plan, and of the immense variety in the forms of matter which compose it, seem to be considerably enhanced by the views now put forth respecting its structure.

BOTANY.

A new Fragaria.—Mr. G. W. Clifton, of Buffalo, U.S., gives (*American Naturalist*, June) an account of a new species of strawberry which has been brought from Jalapa, Mexico, last autumn. It is known in Michigan as the Mexican Ever-bearing Strawberry, and, according to most reliable testimony, it deserves its name. From early June into October—indeed so long as sunlight has strength to ripen berries—it is busy in putting forth fresh flowers and maturing fruit. It is hardy and exceedingly prolific. Its fruit is large, firm, fragrant, sweet, and exquisitely flavoured. It belongs to that section of the genus which bears its achenes, or carpels, superficially on the

receptacle, and is distinguished from all its congeners by its dichotomous stem and racemose flowers.

The Botany of Shetland.—Mr. Alexander Christie, who has been lately on an excursion to Shetland, gave an account of his observation of the flora to the Edinburgh Botanical Society, April 8. He stated that he had been enabled to add twenty species to the list of plants contained in Edmonston's *Flora of Shetland.* The paper was illustrated by dried specimens of the plants collected, and also specimens of the principal rocks of the different islands.

The Botanical Prize of the Pharmaceutical Society.—The prize for 1870, consisting of a silver medal, is offered for the best herbarium, collected in any part of the United Kingdom, between the first day of May, 1869, and the first day of June, 1870; and should there be more than one collection possessing such an amount of merit as to entitle the collector to reward, a second prize, consisting of a bronze medal, and also certificates of merit, will be given at the discretion of the council. In the event of none of the collections possessing such an amount of merit as to warrant the council in awarding medals or certificates, none will be given. The collections to consist of flowering plants and ferns, arranged according to the natural system of De Candolle, or any other natural method in common use, and to be accompanied by lists, arranged according to the same method, with the species numbered.

The Largest Diameter of Tree-trunks.—It is a curious fact, if it be a true one, that (according to a paper by Musset before the Academy of Toulouse) the large trees of St. Cloud have the widest parts of the trunk always in an east and west direction.

Scandinavian Botany.—So much valuable scientific work is done in Norway and Sweden, and so little is known to English naturalists, that we would call particular attention to a series of reprints of the scientific labours of Scandinavian naturalists now being published by Dr. Lütken, in the *American Naturalist.* The following quotation refers to the papers which recently appeared in *Fries' Journal of Botany*:—Among the papers published in the *Botaniske Notiser*, 1867 and '68 (edited by Prof. Th. Fries, at Upsala), I must cite Professor Andersson's, on the genus Salix, and especially its northern species; Dr. Göes' description of the flora of the West Indian island, St. Barthélemy; Mr. Moë's valuable observations on the influence of the different mineralogical constituents of the soil upon the variation of plants; several papers on the Scandinavian species of *Callitriche, Junci* and *Chareæ, Notulæ-lichenologica,* and other geodesical contributions, among which some observations on the variation of the parts of the cone in the common *Pinus abies* should be particularly noticed by botanists and palæophytologists. In every volume of this highly esteemed journal a complete annual list is given of all botanical papers published in Sweden, Norway, and Denmark.—*American Naturalist*, June.

Appointment of Dr. Trimen to the British Museum.—Dr. Henry Trimen, F.L.S., has been appointed assistant in the Botanical Department of the British Museum. This appointment, though offering great opportunity for botanical investigation, withdraws its holder from medical practice. Dr. Trimen is, however, permitted to retain the Lectureship on Botany at St. Mary's Hospital.

Floral Abnormalities.—At a recent meeting of the Natural History Section of the Literary and Philosophical Society of Manchester, some peculiar deviations from the usual form in plants were exhibited. Mr. Sidebotham exhibited some very fine spikes of *Celsia Cretica*, but, instead of the bright yellow flowers, they were apetalous. He stated that he had grown a number of plants from seed produced from the ordinary form of plant; they threw up fine spikes of flower buds, and, as they appeared a long time in coming into flower, he had examined them and found all without petals, some of the spikes being in seed.—Rev. J. E. Vize, M.A., forwarded a spike of the common Plantain (*Plantago major*, L.) which had bifurcated from the middle of the inflorescence, each portion producing perfect fruits.—Amongst other vegetable monstrosities mentioned was that of a dandelion, which Mr. Hunt had collected some time ago, having several scapes united so as to form a single flat ribbon-like stalk, crowned by the various involucres, more or less blended together.

The Natural History and Chemistry of the Ground Nut (Arachis Hypogæa).—A monograph on this subject appears from the pen of Herr F. A. Flückiger in a recent number of the *Pharmaceutische Zeitschrift für Deutschland*, and is thus abstracted in the *Chemical News* of June 11:—The fruit is known, in English language, as ground-nut, earth-nut, pea-nut, and manilla-nut; in French as *arachide*, or *pistache de terre*. The plant which yields this fruit is a native of tropical and sub-tropical regions, and belongs especially to Africa. The average weight of the seeds contained in the fruit and bearers of the oil is 0·5 grm.; they yield from 38 to 50 per cent. of oil, which consists of a mixture of glycerine compounds and three different fatty acids—arachinic acid, $C_{40}H_{40}O_4$, fusing at 75° C.; hypogœic acid, $C_{32}H_{30}O_4$, fusing at 35° C.; and palmitinic acid, $C_{32}H_{32}O_4$, fusing at 62° C. The seeds contain 28·85 per cent. of protein compounds, 13·87 per cent. of woody fibre, and 7·16 per cent. of gum and sugar.

A new kind of Cotton called Bubuy is now being extensively cultivated in the Philippine Islands, through the exertions of a missionary, Father Rivas. The tree which produces it is of very large size; it begins to yield in its fourth year; after the fifth, it has generally attained the thickness of a man's body. Its pods measure from three to four inches; a hundred of them will make up three pounds of cotton, which, cleansed, are paid for at the rate of nine piastres (45 fr.) per hundredweight.—See *Land and Water* and *Gaceta de los Caminos de hierro.*

Influence of Artificial Light in developing the green colour of Plants.—A paper demonstrating this was recently read before the French Imperial Society of Horticulture by M. Rivière. The following account of an experiment made by Ermens is quoted from a contemporary:—Having placed some roots of endive in one of the cellars where plants are preserved in winter, he found that, at a temperature of 21° C., they, in a few hours, yielded leaves about four inches long, but white. He then lighted gas in the cellar to see what would be the effect produced; and discovered that, under the influence of this artificial light, they turned green in the course of thirty hours.

Why true Cellular Plants are absent from the Coal Measures.—In the extremely interesting and valuable lecture which Mr. W. Carruthers (an old

contributor to these pages) delivered before the Royal Institution (April 16) the lecturer explained why we have no true cellular plants in the coal. The long-continued maceration, said Mr. Carruthers, to which the coal plants were subjected when the beds composed of the remains were forming on the surface of the earth, and the subsequent changes they have undergone, have reduced to one common structureless mass the varied vegetation of which the coal is composed. One of the first results of these operations would be the disappearance of the cellular plants which under the then existing very favourable conditions must have abounded; just as the soft cellular parts are almost always destroyed of those specimens which have been so favourably situated as to have their vascular tissues preserved.

The Physiological Phenomena of Plants explained Physically.—Those who have paid any attention to the recent progress of physical research are aware that M. Becquerel has lately described some very remarkable phenomena, under the title of Electro-capillarity. Quite recently he has been applying these observations to physiology, and in the *Comptes-Rendus* for June 7 he attempts, by means of electro-physics, to explain some of the functions of plants. His experiments on the tissues of plants, which he regards as made up of a number of electro-capillary couples, lead, he says, to the following results:—1. The stem of a dicotyledonous woody plant consists of two distinct parts, separated by a substance which is the principal element in growth, the outer part is the bark, the inner the wood. 2. The wood is formed of medullary rays, woody bundles, and of a cellular tissue called the pith, and of concentric layers; the bark likewise includes a fibrous and cellular element, only these parts are inverted: the parenchyma, which is analogous to the pith, occupies the outer part of the bark, while the pith is in the centre of the woody tissue. This inversion has electrical analogues. 3. In the wood one finds an electrical condition contrary to that of the layer which follows or which precedes it. 4. The central part, or pith, is always positively electrified, in relation to the woody layers, and these are less and less positive as one approaches the bark. In the latter the conditions are reversed. M. Becquerel then describes a number of very interesting experiments tending to support his idea that the motion of the fluids of plants is due to phenomena of electro-capillarity.

CHEMISTRY.

Positivism and Idealism in Chemistry.—The following remarks, which we commend to the serious consideration of some chemists of a too speculative turn, were made by Dr. Odling in his recent lecture before the Royal Institution:—"The existence of a determinate structural arrangement in chemical compounds is demonstrated by a host of considerations; but the difficulty of making out the actual structure of individual compounds has hitherto proved insuperable. The facility of setting forth imaginary structure, however, is very great; and accordingly the presentation of imaginary for ascertained structure has been freely practised by chemists from the first introduction of chemical formulæ until now. But in what degree soever a

determination of absolute chemical structure may hereafter be achieved, the possibility exists very generally, even at the present day, of determining relative chemical structure—of making out that in such and such a body the structural arrangement is similar to, or different from, that of some other and usually more simple body. Hence the importance of studying the structural analogies of the simplest organic bodies."

The Analysis of Phloron.—A paper on this subject was recently laid before the Royal Academy of Science of Munich by Herren Von Rath and Von Gorup. The facts of the paper relate chiefly to the method of preparing this substance from tar containing a large percentage of creosote. The elementary analysis of the phloron drawn from creosote of a particular form of tar gave results which accord very closely with the calculated results: 0·252 grammes gave 0·6514 of carbonic acid, and 0·1408 of water.

		Calculated	Found
C_8	96	70·58	70·49
H_8	8	5·88	6·17
O_2	32	23·54	23·34
	136	100·00	100·00

The Xylol of Coal Tar.—Herr Filteg recently sent a note on this substance to the Society of Sciences of Göttingen. The paper is a long one. The author opposes all opinions hitherto expressed. He says it is certain that paranitrotoluylic, parachlortoluylic, and parabromtoluylic acids, are not products of substitution of toluylic acid proper. He thinks rather that by retrograde substitution an acid may be obtained which is isomeric with toluylic acid, and which by strong oxidation will not give terepthalic, but isophtalic acid.

A Beautiful Chrome Green has been produced by M. Casthelaz. The method employed is the wet one. The process consists in slowly precipitating chrome salts by treating them with hydrated metallic oxides, insoluble, or but slightly soluble, in water, or by hydrated metallic carbonates, or hydrated metallic sulphides, or again, by salts of weak acids, which easily leave their bases; the action is only produced progressively, and the oxide of chromium is precipitated in the hydrated form; the colour of the compound is magnificent, of a deep emerald green. For this preparation, it is convenient to adopt economical reagents, such as gelatinous alumina, oxide of zinc, carbonate of zinc, sulphide of zinc, &c., whose price is reasonable. The same result may be obtained by treating a chrome salt with the non-alkaline metals, which have a sufficient affinity to unite with the acid of the chrome salt and precipitate the oxide. Iron and zinc will be more particularly used, as they are cheaper. It is necessary to select from among the metals, with their oxides and salts, those which, with the acid of the chrome salt, give soluble salts as they should be removed by washing. If recourse is had to reagents forming, with the acid of the chrome salt, insoluble salts, it is only in order to modify the colour and composition of the chrome precipitates and of the green colour thus formed. As to the magnificent imperial green colour obtained by M. Casthelaz, it possesses properties which will enable manufacturers ultimately to renounce the justly condemned and dangerous copper and arsenic greens. The use

of the imperial green removes all danger from insalubrity; it is an impalpable substance, of perfect tenuity. It is believed that this property will cause the new green to be adopted for printing on stuffs, and for other purposes. The oxides of chrome known up to the present time, and generally obtained in the dry way, cannot, by pulverisation, attain to the degree of fineness of the imperial green. It is expected that this substance will have great success in oil painting, coloured papers and artificial flowers, printing, lithography, perfumery, and soap manufacture, as well as in the making of glass and in the ceramic arts.—Vide *Artizan*, April.

Death of M. Nikles.—M. Nikles, who held the chair of Chemistry in the Faculty of Sciences at Nancy, has died during the past quarter. He had reached the age only of forty-nine years. His disease was an affection of the lungs, brought on by some researches in fluorine compounds.

Decomposition of the Sesqui-salts of Iron.—At the meeting of the French Academy on the 19th of April, a memoir was presented from M. Debray. "When," says the author, "we heat a solution of neutral chloride of sesquioxide of iron, so dilute that its colour is hardly perceptible, when it reaches to above 70° Cent. it becomes decidedly coloured, and assumes the characteristic tint of the basic chlorides of the sesquioxide. This transformation is not due to the disengagement of hydrochloric acid, since the transformation can be effected in closed vessels, and the colour is maintained on cooling. The chemical properties of the iron salt are profoundly modified; thus, whilst the primitive liquor gives with the yellow prussiate of potash an intense precipitate of prussian blue, the coloured solution gives with this reagent but a pale greenish blue precipitate; also sea-salt, which has no action in the colourless solution, gives with the modified chloride a gelatinous precipitate of hydrated sesquioxide of iron." The author concluded by expressing the hypothesis that the iron is reduced by the temperature to a colloidal condition, which is kept in solution either in hydrochloric acid or in sesquichloride of iron.

Artificial Preparation of Alizarin.—At a recent meeting of the Literary and Philosophical Society of Manchester, Professor Roscoe described the discovery, by MM. Graebe and Liebermann, of the artificial preparation of alizarin, the colouring matter of madder, from anthracene or hydrocarbon found in coal tar. It appears that the formula given for alizarin many years ago by Dr. Schunck—viz., $C_{14}\,H_{10}\,O_4$, corresponds closely to the composition which the substance is now found to possess—viz., $C_{14}\,H_8\,O_4$. We are as yet unaware how alizarin is obtained from anthracene $C_{14}\,H_{10}$. The artificial colouring matter appears to possess all the properties of the madder alizarin, and the ordinary mordants yield the well-known colours in every respect identical with those obtained in the well-known processes of madder-dyeing. The importance of this discovery can hardly be overestimated.

The Chemistry Professorship of Edinburgh University.—Dr. Crum Brown has been appointed Professor of Chemistry in Edinburgh University.

Modus Operandi of Creosote.—Mr. P. Moir, in the Glasgow Philosophical Society Reports, thus expresses the properties of this substance as a preservative:—"1. It coagulates albuminous substances and gives stability to the constituents of the cambium and cellulose of the young wood. 2. It

absorbs and appropriates the oxygen which is within the pores of the wood, and so checks, or rather prevents the eremacausis of the ligneous tissue. 3. It resinifies within the pores of the wood, and in this way shuts out both air and moisture. 4. It acts as a positive poison to the lower forms of animal and vegetable life, and so protects the wood from the attacks of fungi, acari, and other parasites. Since the creosoting process was first introduced in the year 1838 it has been extensively employed in Great Britain and Ireland; in all countries on the Continent where creosote oil can be obtained—France, Holland, Belgium, Germany, Spain, Portugal, and Italy; and in India, Cape Colony, Brazil, and other tropical countries, to preserve timber from the attacks of the white ant. Wherever it has been properly carried out it has been completely successful."

Supersaturation of Sugar Solutions in Alcohol.—The *Chemical News* gives the following abstract of a note in the *Comptes-Rendus* of May 10. On behalf of M. Margueritte, M. Sainte-Claire Deville read a note setting forth the objections they have to make against the theory of M. Dubrunfaut concerning the supersaturation of sugar solutions in alcohol. The author says that Dubrunfaut has not proved by any experiment that when crystallisable sugar is dissolved in water, and alcohol added, any change should take place in the sugar itself. It is, therefore, evident that nothing else happens than the return to the solid state of a substance previously dissolved, and the crystallisation of which was impeded either by the presence of water, or some other unknown cause.

The Chemistry of Nitroglycerin.—M. Tilberg has made some researches on this substance, making use of the nitroglycerine manufactured on the large scale at Stockholm. This material is decomposed by potassa, giving rise to the formation of nitrate of potassa and glycerine; but, at the same time, there are formed secondary products, as ammonia, cyanogen, oxalic and ulmic acids, and nitrous acid. According to the results of elementary analysis made by the author, the formula for this kind of nitroglycerine should be $C_3H_5(NO_2)3O_3$. The substance is soluble in concentrated sulphuric acid, yielding a clear solution, and forming a sulphoconjugate which, on being combined with bases, gives crystallisable salts.—Vide *Chemical News*, May 21.

The Preparation of Artificial Ebony.—This substance is now being manufactured on a tolerably extensive scale. It is prepared, says a contemporary, by taking sixty parts of seaweed charcoal, obtained by treating the seaweed for two hours in dilute sulphuric acid; then drying and grinding it, and adding to it ten parts of liquid glue, five parts gutta-percha, and two and a-half parts of india-rubber, the last two dissolved in naphtha; then adding ten parts of coal tar, five parts pulverised sulphur, two parts pulverised alum, and five parts of powdered resin, and heating the mixture to about 300 deg. Fah. We thus obtain, after the mass has become cold, a material which in colour, hardness, and capability of taking a polish, is equal in every respect to ebony, and much cheaper.

A New Work on Chemistry is now in the press, and will shortly be published by Messrs. Longman. The author is Dr. Odling. The volume will consist of the notes from which the author has lectured for the last six years at St. Bartholomew's Hospital, revised and somewhat extended, so as to

furnish the student with a connected outline of the leading facts of chemistry in their relations to each other. It will be essentially descriptive in its character, and aim at calling to mind, in as few words as possible, the ascertained origins, properties, and metamorphoses of chemical substances. It will include a systematic account of the monad, diad, and triad non-metallic elements, and their principal combination with each other; of silicon and carbon with its series of methylic, formic, and cyanic compounds; and of the various metals, arranged, as far as practicable, in natural groups, with their respective series of halides, oxides, and oxisalts, &c.

The Constitution of the Coal-tar Gases is the title of a paper some time since read before the Vienna Academy by Herr Tulsowski. His observations tend to prove that the entire series of these basic substances, with their numerous derivatives, take their origin most probably from one and the same carbide of hydrogen, the as yet hypothetical combination triphenylene.

Citric and Isocitric Acid.—Herr Rochleder of Prague publishes the following abstract of a recent inquiry on these acids:—A solution of citric acid, whose permanence is insured by the addition of dilute sulphuric acid, when placed in contact with sodium amalgam, gives rise to an acid of the same composition as citric acid—isocitric acid—which may be obtained pure by simply decanting. From this, isocitrate of lead may be procured in the ordinary way, and by decomposing this by sulphuretted hydrogen the acid is obtained perfectly pure. It soon solidifies to a mass containing long and delicate crystals. The isocitrates are very little known; when submitted to dry distillation, they hardly give any product but citraconic acid.

The New Laboratory at Leipsic, which has been completed, is said to be the largest and most commodious one in all Germany.

A Phosphorus Holder.—A suggestion has been made by Mr. E. Kernan, in a letter to the *Chemical News*, June 11th, which, we doubt not, may be found useful by lecturers and others engaged in demonstration:—A few inches of lead tube, $\frac{1}{4}$-in. bore, is contracted to an open cone, at one end. As much phosphorus as one may choose is put into the cone of the tube; the phosphorus is made to project slightly from the cone; the upper part of the tube is filled with water, and corked. Thus is had a phosphorous "crayon" perfectly safe in the hand for luminous writings, &c. To put in the phosphorus, as much as may be required is melted in a conical glass, or test-tube, the cone of which is larger than that of the lead tube. This is put standing in the melted phosphorus, which fills the cone and tube to its own outside level. When cold, there is a nice projecting crayon, from the form of the glass. Any phosphorus outside the lead tube may be melted off. To renew the writing point, a test-tube, conical below, is fitted to the cone of the lead; the whole held in warm water for a minute, as much phosphorus flows out as forms a new point.

Pressure and Chemical Action.—The *Engineer* states that M. Castletel continues his researches on these points. In one of his experiments sulphuric acid remained for twelve days in contact with an excess of zinc in a revolving tube hermetically closed, without becoming saturated, and sodium amalgam remained pasty in water in the same circumstances.

The Colouring Products of Garance.—According to Herr Rochleder, the root of garance, treated with the dilute mineral acid, supplies, besides

alizarine and purpurine, a small quantity of a third substance, which in composition is allied to these two. The colour of its alkaline solution is almost the same as that of the alkaline solution of chrysophanic acid. Acids precipitate it as a gelatinous, flocculent, and amorphous mass, of a pale yellow colour. It crystallizes from the alcoholic solution in orange-yellow needles, and from the acetic acid solution in pale citron needles. The aqueous solution, impregnated with acetic acid and boiled with silk, gives this a beautiful golden yellow dye.

The Synthesis of Creatine.—At a late meeting of the Bavarian Academy, Herr J. Volkard read a paper on this subject. The author has already shown that sarcosine is methylamidoacetic acid, or acetic acid into the radical of which a residue of methylamine enters, having obtained it synthetically from chloracetic acid and methylamine. Having effected this synthesis he endeavoured, without success, to combine the sarcosin directly with the residue of urea, and so get creatine, thereby demonstrating synthetically the correctness of the view of the constitution of creatine founded on its analysis. He then imitated Herr Strecker's synthetical method of forming glycocyamine in which glycocol is united to cyanamide. Glycocol bears the same relation to sarcosin that glycocymine bears to creatine. By bringing together sarcosin and cyanamide in solution, in water or alcohol, small portions of creatine are formed, the formation being rapid at a boiling heat. The author showed by a number of analyses and reactions that the creatine so obtained is completely identical with that obtained from meat-broth and from urine.

Balsam of Peru.—In a paper published in the Proceedings of the Kaiserliche Akademie of Vienna, Herr Kachler says that this substance suits well for the preparation of benzylic alcohol, free from admixture with other bodies. The balsam contains a notable quantity of cinnamate of benzylic ether, together with a resinous substance, which, treated with hydrate of potash, gives benzoic acid and protocatechuic acid. The same hydrate serves for obtaining the benzylic alcohol from the cinnamate of benzylic ether. A hundred parts of balsam of Peru yielded resin 32, benzylic alcohol 20, crude cinnamic acid 46 parts.

Volumetric Estimation of Sulphuric Acid.—A new feature in the *Chemical News* is an excellent series of abstracts of all the foreign memoirs on chemistry and physics. From this we select the following account of a method published in *Dingler's Polytechnisches Journal*, by the Rev. Dr. A. Coleman:—The solution to be experimented upon is coloured with litmus, and very carefully neutralised; a solution of chloride of barium of known strength is added in excess, and all the sulphuric acid thereby precipitated. Next, a titrated solution of carbonate of soda is added, in order to precipitate the excess of baryta; and next, again, the excess of soda solution used is estimated, volumetrically, by means of a titrated dilute sulphuric acid. During these operations no salt is formed which can injure the colour of the litmus. In case salts might be present in the original solution, the bases of which could be precipitated by carbonate of soda, that precipitation is performed previous to the addition of soda. The filtrate, which contains the sulphuric acid combined with soda, is neutralised, and again volumetrically titrated. The solutions required for this experiment are:—A solution of chloride of

barium, containing 52 grms. to the litre of water; a solution of carbonate of soda, containing 26·5 grms. of this salt to the litre of water; a solution of sulphuric acid, containing 20 grms. of strong sulphuric acid to the litre of water. These solutions agree among each other, drop by drop. The advantage claimed for this method is the non-necessity of having to wash out the sulphate and carbonate of baryta, and also the advantage that titration does not take place in a fluid rendered turbid by therein-suspended sulphate of baryta, which always tends to render the observation of colouration of litmus more difficult.

GEOLOGY AND PALÆONTOLOGY.

The Sediment of Rivers.—This is a subject which, much as it has been studied, still affords room for abundant research, as may be seen by referring to the *Geological Magazine* for April. In this journal there is a paper of much interest by the Rev. J. D. De la Touche. The author recently made a number of experiments in the river Onny which flows by his house. The following is an abstract of these:—1. A tolerably straight and uniform reach of the river was chosen, and along the bank 100 feet were measured and marked by pegs driven into the ground. Here a marked post was erected in the water, to take the height of the flood from time to time. This was done every day after any considerable fall of rain, and at the same time the rate at which the centre of the stream moves was ascertained, by counting with a watch the number of seconds any floating substance takes to pass the measured 100 feet. 2. An accurate section of the river was made by sounding. From these data the number of cubic feet of water which pass this point in a given time could be calculated, by knowing the ratio of the speed of the centre to the mean velocity of the whole stream. An able practical engineer, who had had much experience in this matter, stated that is represented by the fraction four-fifths. But it seemed to the author that this rule can hardly be very accurate, and that it would be desirable to find the mean velocity by the use of a current mètre, working in different parts of the section. However, this element once determined, it is of course only necessary to multiply the area of the section in feet, by the mean velocity in feet for a given time, to ascertain the number of cubic feet which flow past in that time. 3. The proportion of sediment held in suspension was ascertained by collecting a certain measure of water (a quart bottle answers the purpose very well), and then decanting and filtering it. If the filter be carefully dried and weighed, before and after the experiment, the difference gives the weight of mud from which the per centage of grains to ounces of water can be obtained. Thus there are supplied sufficient data to determine how much solid matter passes down the river in a given time at any flood. 4. Besides these observations, the rainfall at different points of the watershed of the river should be carefully registered. Thus some correlation between the two could probably be ascertained, so that from year to year an average rate of the wear and tear of the surface of the land might be obtained.

The Geology of Alaska.—The following is an extract from a letter ad-

dressed by Mr. W. H. Dall of the Washington Smithsonian Institute to Mr. Whymper. "You can tell your scientific friends that I have settled the geological question by fossils which I got this last year near Topanica (Norton Sound): a fine species of *Platanus*, which is undoubtedly Miocene Tertiary; there are no older rocks below Nuclukayette (Yukon River). The south flanks of the Alaskan range have Triassic? and Miocene Tertiary beds."

American Coal Insects.—A very valuable memoir on the fossil articulata of some of the American coal measures has been prepared by Messrs. Meek, Worthen, and Scudder. It is published in the form of advance sheets of *The Report of the Illinois State Survey.*

A curious fossil Tubularian Zoophyte—At the meeting of the Royal Society on June 17, Dr. Duncan described a very remarkable fossil which seems to be intermediate between the Hydrozoa and the Echinodermata. It appeared to be parasitic on a Polyzoan and measured about an inch in length. It had a hard skeleton like a comatula, but had not any jointed structure whatever.

The Structure of Sigillaria formed the subject of a paper read before the Geological Society of London (March 24), by Mr. W. Carruthers. The author indicated the characters of the medullary rays of dicotyledonous stems, and stated that these stems have a vascular horizontal system connected with the axil organs, in which respect the dicotyledonous and acrogenous stems agree. The woody columns of *Stigmaria* and *Sigillaria* are destitute of medullary rays, the structures previously described as such being the vascular bundles running to the rootlets and leaves. Hence the author concluded that *Sigillaria* is a true cryptogam, a position supported by the characters of the organs of reproduction as described by Goldenberg. The paper concluded with an enumeration of the forms of fruits belonging to *Sigillaria* and its allied genera, with indications of the existing forms to which they most nearly approach.

Catastrophism and Uniformitarianism.—Professor Huxley in his recent anniversary address, thus happily expressed the relation of these two schools:—"To my mind there appears to be no sort of necessary theoretical antagonism between Catastrophism and Uniformitarianism. On the contrary, it is very conceivable that a catastrophe may be part and parcel of uniformity. Let me illustrate my case by analogy. The working of a clock is a model of uniform action; good time-keeping means uniformity of action. But the striking of the clock is essentially a catastrophe; the hammer might be made to blow up a barrel of gunpowder, or to turn on a deluge of water; and, by proper arrangement the clock, instead of marking the hours, might strike at all sorts of irregular intervals, never twice alike in the intervals, force, or number of its blows. Nevertheless, all these irregular and apparently lawless catastrophes would be the result of an absolutely uniformitarian action; and we might have two schools of clock theorists, one studying the hammer and the other the pendulum.

The Carboniferous Limestone of Belgium.—The Bulletin of the Royal Academy of Sciences of Belgium contains a report of a paper by MM. Cornet and Briart on the Carboniferous Limestone of Soignies. The authors' observations were made on some deposits recently opened in the course of public operations. The deposits in question present themselves as a bed of

variable thickness, inclined to the south at an angle of from 3 to 8 degrees. Some parts of these sediments contain pyrites more or less altered, *limonite*, and scales not determined.

Plants from Brazilian Coal-beds.—In the *Geological Magazine* for April, Mr. W. Carruthers gives an account of his examination of certain fossils, placed in his hands by Mr. N. Plant, and which came from Rio Grande do Sul. The coal contains no recognisable fossils, but they abound in the shale. The substance of the plants is converted into a brittle coal, that possesses no structure, and exhibits the form only of the organism, but the superficial structure and the venation is often so beautifully preserved on the surface of the shale, when the coal is removed, that the nature of the fossils is very clearly exhibited. He has thus been able to determine with precision three species, and to recognise more vaguely a number of other forms, which, however, it would be injudicious, until additional material is obtained, to name or describe from the specimens in his possession. All these forms, as far as they can be determined, and certainly the three well-preserved species, belong to Palæozoic genera, species of which occur in the coal-measures of Britain. We are thus, says the author, enabled with certainty to refer the coal-fields of the province of Rio Grande do Sul to the Carboniferous period, although the coal itself has more the aspect of being the product of a Secondary formation. The three species which he describes in this paper are new forms belonging to the genera *Flemingites*, *Odontopteris*, and *Noeggerathia*. The most interesting of the three is the species of *Flemingites*, of which there are a large series of specimens of the stems and foliage, as well as of the detached sporangia.

Organisms in Volcanic Rocks.—According to the statement recently made in a memoir published by Herr Jenzsch, of Gotha, this savant has found, in volcanic and crystalline rocks, minute animal and vegetable forms in prodigious numbers and in a fossil condition. Some of these minute creatures he describes as having been petrified in the midst of their "life functions." Among them he finds Infusoria and Rotifera, intermingled with algæ, and he infers their formation in a large expanse of stagnant water.

Prehistoric Archæology.—The following are the members of the Committee of the Ethnological Society appointed to examine British Prehistoric remains:—Sir John Lubbock, Professor Huxley, Colonel Lane Fox, Mr. Hyde Clarke, Mr. John Evans, Mr. Thomas Wright, Dr. Thurnam, Mr. H. G. Bohn, Mr. Blackmore, and Mr. A. W. Franks.

The origin of the Derwentwater Depression.—At a meeting of the Geological Society of Edinburgh, on the 18th of April, Dr. H. A. Nicholson read a paper on the geology of Derwentwater. Among other phenomena which he sought to explain was that of the depression in which Derwentwater was situated. With regard to this he held that it is to be ascribed to the ordinary denuding agents, but especially to glacial action. At the same time he could not doubt but that the faults which he had shown to exist had powerfully co-operated in the production of the valley. He did not suppose that faults caused open fissures, which were subsequently widened into valleys; and he was not aware that any one held this view. On the contrary, it was simply held that faults might constitute lines of weakness along which denuding agencies would meet with less resistance than elsewhere; this

being partly due to the inevitable breakage and disturbance of the rocks near the line of fracture, and partly to the fact that rocks of unequal hardness were often opposed to one another for a great distance in consequence of the displacement. This latter cause was specially manifest in the case of Derwentwater—one side of which was composed of the comparatively yielding Skiddaw slates, and the other of the igneous series of the green slates and porphyries. And there were unmistakable proofs that this was due to faulting, and was not caused by the want of conformability, which the author had recently shown to exist between the two formations in question.

Fossil Plants of Greenland.—In his report presented to the Royal Society (April 7), Professor Oswald Heer, in his summary of the botanical results of his late arctic expedition, announced the identification of fourteen species from Disco Island, among which *Platanus Guillelmæ* (Göpp.) and *Sequoia Coutesiæ* (Hr.) are the most common. Of *Magnolia Inglefieldi*, a species originally identified by means of leaves found at Atanekerdluk, two cones were found in the Disco beds, thus corroborating the previous determination, and proving that this splendid evergreen ripened its fruit so far north as on the parallel of 70°. Seven out of the Disco species occur also at Atanekerdluk, and eight agree with those of the Lower Miocene of Europe. The age of the deposit is accordingly well ascertained. The collection from Atanekerdluk contains seventy-three species, of which twenty-five are new to Greenland. Some of these are known European forms, especially *Smilax grandifolia*, which, at the Miocene epoch, occurred over the whole of Europe. Of *Sequoia Langsdorffii*, as was to be expected, abundant evidence has been accumulated, showing how favourable the conditions of climate and soil were to its growth. Among the most interesting specimens are the flowers and fruit of a chestnut, the latter in a very imperfect condition. The discovery of these proves that the deposits in which they are found were formed at different seasons, in spring as well as in autumn. The Miocene plants of Greenland have now reached the number of 137 species, and those of the Arctic Miocene flora 194. Of the Greenland species 46, or exactly one-third, agree with those of the Miocene deposits of Europe. The determination of the age of the beds as Lower Miocene has accordingly been confirmed. Four of the species agree with those of Bovey Tracey, among them *Sequoia Coutesiæ*, the commonest tree in the latter locality. In concluding the first part of his paper, the author offers a *résumé* of the grounds on which the determinations of the species have been based. Seventeen species are represented by the leaves and organs of fructification among the Greenland specimens. Ten species are only represented by leaves in Greenland, but their organs of fructification occur elsewhere. Seventeen species, of those of which only leaves are found, exhibit, however, such marked characteristics, that there can be no doubt about their identification. Five cryptogams have been satisfactorily recognised. Accordingly, though it must be allowed that the systematic position of many of the plants from North Greenland is as yet uncertain, yet the considerable number of absolutely identified species which can be produced enables us to form a clear idea of the Miocene flora of North Greenland.

Subterranean Lava Tides.—The idea of a regular tidal flow of fluid lava is

strongly opposed by Mr. G. P. Scrope, in a recent number of the *Geological Magazine*. After enumerating a variety of facts, he says, that such facts have brought him to the conviction that though there may be occasionally lateral flows of lava beneath the surface of a volcano, from an interior pool, through fissures opening outwards at a lower level—as in the *tappings* of the lake of Kilauea, so frequently witnessed—yet, in general, lava solidifies so rapidly and readily from increase of pressure or diminution of temperature, that no very extensive accumulations of such matter in a fluid state are likely to exist even beneath an active volcano, still less below vaster areas of the earth's crust, and that the apparent connection of one volcanic vent with others in its neighbourhood, or belonging to the same chain, is rather due to the lateral transmission or escape of heat than to the actual transference of liquid matter between one and the other. Many facts tend to show that "lava," the only fused rocky matter in nature with which we are acquainted, is, when it issues from the interior of the earth during volcanic eruptions, extremely viscous; and though some currents are seen to flow down an incline so low as 6° or 8° with a velocity of three or four miles an hour, others are so sluggish as to accumulate in bulky masses beside or over the orifice whence they are expelled. "If," says Mr. Scrope, "it be suggested that in the depths of the volcano the fluidity of the lava is probably very much greater, owing to its higher temperature, this idea is, I think, inconsistent with many well-known facts, such, for example, as the occasional efflux of liquid lava from the summit of Mauna Lòa in Hawaii, while that in the crater of Kilauea at a level of 10,000 feet lower, and only sixteen miles distant, remains unaffected."

MECHANICAL SCIENCE.

New Rifle.—After a long and laborious investigation, the Ordnance Select Committee have recommended the adoption by Government of the Martini-Henry rifle, in place of the Snider rifle now used. The former has only twenty-seven pieces in the breech against thirty-nine in the latter; the arrangement of the parts is stronger; the manipulation more simple, and the cost less. The Martini-Henry rifle of 0·45-inch bore, has a much lower trajectory than the 0·5-inch and 0·577-inch Snider, it is more accurate especially at long range, and the penetrating power of its bullet is greater.

Liquid Fuel.—Captain Selwyn has published the results of further experiments on the use of liquid fuel. Although Captain Selwyn does not appear to maintain the exaggerated estimate of the evaporative duty of liquid fuel which he once entertained, he still seems to think that the whole theoretical heat of combustion may be utilised. So far as the experiments go, it has not yet been shown that in the ordinary conditions of practice a pound of liquid fuel will evaporate more than fifty per cent. more water than a pound of the best coal properly burnt. Some other applications of liquid fuel possess much interest. Boiler-plate heating furnaces at Woolwich and Chatham have been fitted with Messrs. Dorsett and Blyth's apparatus, already de-

scribed in these pages,* and have been successfully worked with liquid fuel. In such a furnace the efficiency depends rather on the intensity of the heat produced than on its quantity, and it is quite possible that liquid fuel may be burnt with a much smaller proportion of air, and that a high and steady temperature may be the more easily and economically maintained than with coal. This result appears to have been attained at Woolwich, the furnace being worked at a less consumption of fuel, and the plates heated in a shorter time with oil than with coal.

Steam Engine Performance.—In the ordinary mode of comparing the duty of steam engines by determining the quantity of coal necessary to develope a given power, the efficiency of the boiler is not distinguished from the efficiency of the engine. Mr. B. W. Farey and Mr. Bryan Donkin have recently made some interesting experiments with an apparatus designed to measure directly the heat carried away in the condenser. Measuring at the same time the work developed by the engine, by means of indicator diagrams, all the elements are ascertained, necessary for determining the efficiency of the engine independently of the boiler. The quantity of water passing through the condenser is measured by conducting it over a weir or notch. The temperature of the condensing water on entering the condenser and that of the mixture of injection water and condensed steam leaving the condenser, is ascertained by ordinary thermometers; lastly, the work done in the cylinder is ascertained by indicator diagrams. Dividing the horse power developed in the cylinder, expressed in thermal units, by the quantity of heat imparted to the injection water in thermal units the quotient expresses nearly the efficiency of the steam. And since the efficiency of the steam in the same engine does not vary much for moderate variations of power, when the efficiency of the steam has once been ascertained the measurement of the volume and temperature of the injection water affords a new means of ascertaining the work done by the engine. Messrs. Farey and Donkin have therefore contrived photographic registering apparatus, by which the volume of flow and temperature of the injection water is continuously recorded. The data so obtained being used either to determine the efficiency of the steam; or, if the efficiency of the steam is known, to determine approximately the power of the engine.

Mr. Reed on Iron-Clads.—Mr. E. J. Reed, the Chief Constructor of the Navy, has communicated to the Institute of Naval Architects a valuable exposition of his views on the advantages of short over long iron-clads, with an abstract of his paper previously presented to the Royal Society.

Mr. Reed believes that it is unwise to make an iron-clad very long, large, costly, and unhandy, in order to effect a comparatively small saving in engine power. Hence he has introduced into the navy vessels in which the length is only five and a half times the breadth, instead of being six and a half times as in earlier armour-plated vessels. The reason why the disadvantages of excessive length are more apparent in iron-clad than in other vessels is that, in them, a great part of the weight to be carried is in the armour, and is dependent on the form of the vessel. Any addition to the length leads to a corresponding increase in the area of the surface to be armoured

* Vol. viii. p. 93.

and in the unproductive weight to be carried. In the merchant-ship the load to be carried is nearly independent of the form, and any diminution of engine power required to drive the vessel, due to form, is pure gain. In the iron-clad, the diminution of engine power, by increasing the length and the fineness of the vessel's lines, involves simultaneously an increase in the surface to be armoured and of the tonnage of the vessel. Mr. Reed points out that in the only instance in which long and short iron-clads have been tried under precisely similar conditions, the six hours' trial of the "Minotaur" (400 feet long) and the "Bellerophon" (300 feet long), when both vessels were working at 6,200 indicated horse power, the former made 14·165 knots, and the latter 14·053, the former having been a somewhat shorter time in the water, and having, consequently, a cleaner bottom. So that in this case, with the same engine power, the speed of the two ships was practically identical. The economy of cost of construction in the type of short ships introduced by Mr. Reed is very considerable.

Resistance of Armour-Plates.—Dr. Fairbairn has given, in a paper read before the Institute of Naval Architects, a full account of the experiments of the Iron Plate Committee, from 1861 to 1864, so far as they bear on the power of iron plates to resist projectiles, and on the qualities most desirable in armour casing.

Joints of Pipes for Gas and Water Mains.—Mr. Barker has described to the Society of Engineers a new joint for pipes, designed to obviate the great loss from leakage with the joints in ordinary use. Mr. Barker uses spigot and faucet pipes, but he casts on them a coarse pitched screw thread. When the spigot is placed in the faucet, one turn serves to screw the pipes up to a bearing, and at the same time a layer of moist cement introduced into a conical recess is compressed so as to form the joint.

Palliser Bolts.—It is proposed to use the Palliser bolts, which have been so successfully applied for armour-plating purposes, for the fish and fang bolts of railway permanent way. The principle of the Palliser bolt has already been alluded to in these pages,* and there seems no reason why it should not be as suitable for resisting the impacts to which railway fastenings are subjected, as the concussion of projectiles.

MEDICAL SCIENCES.

The Relation of the Osseous Medulla to the Blood.—The *British Medical Journal*, in abstracting a recent paper, by Herr Neumann, in the German *Centralblatt*, calls attention to the fact that Neumann's startling theory that the marrow developes blood-cells, has received confirmation by the observations of M. Bizzozero. Among other things, this observer says that the condition of the marrow in the bones of frogs in winter, as compared with summer, furnishes an important argument in favour of the theory that marrow is a blood-gland. In winter, the white corpuscles in the blood of the frog are not half so numerous as they are in summer; and in winter the

* Vol. iii. p. 538.

marrow consists almost entirely of fat-cells, whereas in summer it contains hardly anything but lymphoid cells. He examined the costal marrow and the spleen in five cases of death from typhus fever, and observed in both structures an enormous increase of cells containing blood-corpuscles.

The Physiological Effects of Lightning.—Professor Pepper's great induction coil at the Polytechnic has afforded Dr. Richardson an opportunity of carrying out a number of extremely interesting experiments on the effects of powerful electric shocks on the animal body. In a lecture delivered at the Polytechnic, Dr. Richardson summarised the results of some of his researches, and of his summary of the effects of lighthing shock the following is an abstract. 1. Absence of evidence of action of the heart: though it must be remembered that the heart-beat might continue, although it could not be heard. 2. Absence of reflex action: in batrachia, however, this did not always indicate death. 3. Diminution of the animal temperature in the cavities of the body. 4. Absence of colour in the semitransparent structures: this was not a reliable test. 5. *General* muscular rigidity was sufficient evidence of death; but not local or partial rigidity, unless it affected the muscles essential to life, as the respiratory. 6. Coagulation of blood in the veins was a sure sign of death. If, on opening the largest vein that could be reached, the blood were found coagulated, there was no hope of restoring respiration. 7. Decomposition was the final proof of actual death.—*Marks* of various kinds had been described as being left on bodies struck by lightning; and the accounts of some of these had been regarded as chimerical or exaggerated. These marks were: 1, burns; 2, impressions of metallic substances; 3, ecchymoses; 4, supposed impressions of such objects as trees or fences; 5, loss of hair.—1. *Burns* were more likely to be severe when life was not destroyed than when the shock was fatal; they varied in extent, from mere singeing to extensive cauterization. Pins and other metallic articles of dress often led to severe local injuries—the parts injured being those lying between the metallic points.—2. *Impressions of Metallic Substances.* The occurrence of these had been doubted by Faraday and others; but Dr. Richardson had found, by experiment, that the impressions of ornaments, &c., might be faintly struck on the surface of the body. The mark was a pure ecchymosis; and for its production, resistance on the opposite side was necessary. It was not a burn from heated metal; as, under favourable conditions, a simple electric spark would produce it.—3. *Ecchymoses* were sometimes found; as was observed in the case of Professor Richmann of St. Petersburg, who was killed by an electric discharge in 1753, while performing experiments.—4. *Arborescent marks,* wrongly supposed to be impressions of trees, &c., were sometimes found. They were in reality, as was pointed out a hundred and ten years ago by Beccaria, the outlines of the superficial veins of the body. Dr. Richardson had succeeded in bringing out the outline of the veins in the ear of a rabbit, by means of the discharge from a Leyden jar.—5. *Loss of Hair* was observed in some cases where the nervous system was affected.

Experiments with Liebig's Food for Children.—We believe we were the first journal to call attention in this country to this valuable preparation. Indeed we *were* the first to do so, for it was in our pages that Baron Liebig himself described the substance as a soup for infants. We are, therefore,

interested to perceive that at a recent meeting of one of the continental scientific societies, Dr. Kjelberg related his experience of the use of Liebig's food for infants as a remedy. Six cases of diarrhœa occurred in his Children's Hospital among infants of from 1½ to 2 years; five of them had already been treated with medicine without effect. A thin broth made from the "food" was given them as their only nourishment, and all medicine was discontinued. The motions at once assumed a better appearance. In one case, which had no previous treatment, the effect of the exclusive use of Liebig's food was very striking. Dr. Kjelberg says that he had used the treatment in two cases of children, private patients, in whom not diarrhœa, but obstinate constipation was the malady. The children were still suckled, while the food was administered. The peristaltic function of the bowels rapidly became normal and regular. Dr. Kjelberg thinks that Liebig's food possesses the capacity of *regulating* the activity of the intestinal canal.

Opium-eating.—We do not vouch for the accuracy of the statement made in the *New York Medical Record* that Mr. Horace Day (who is said to be the author of a recent American book, "The Opium Habit") has eaten over fifty pounds of opium.

What are the Actual Effects of Absinthe on the System.—Many of the memoirs in the *Comptes-Rendus* are more remarkable for the distinctness with which the conclusions they set forth are expressed, than for the sound evidence on which such conclusions are based. We won't say that this applies to the following. But, as the question of the effect of absinthe is often asked, we shall lay the following conclusions of M. Magnan before our readers:—1. The epileptic or epileptiform accidents in alcoholism—or, in other words, alcoholic epilepsy—are of a radically different nature, according as the alcoholism is acute or chronic. 2. In acute alcoholism the epilepsy is under the complete influence of an external agent, of a poison (absinthe) which of itself alone causes the epileptic attack; it is epilepsy by "intoxication." 3. The alcoholic epileptics exhibit the ordinary features of simple alcoholic cases, and also superadded phenomena, among which the epileptic attack is dominant. 4. These two groups of symptoms (the alcoholic symptoms and alcoholic convulsions), united in the same subject, have a relation to the twofold nature of the poison (absinthe), whose elements are absinthe and alcohol. 5. In chronic alcoholism the epileptic or epileptiform accidents are under the direct control of organic modifications which take place in the patient. The excess of liquids, in gradually altering the tissues, renders them capable, under the influence of various causes, of producing by themselves convulsive epileptiform phenomena, accidents analogous to those that we see take place in other patients in certain cases of lesions of the nervous centres (general paralysis, tumours of the brain, &c.). (*Comptes-Rendus*, April 5.)

An Anatomist decorated.—Professor Brunetti, the celebrated anatomist, of Padua, has been decorated with the orders of St. Anne of Russia and St. Gregory the Great of Rome. This last honour, says *L'Imparziale*, has been conferred on him as a consequence of the illustrious astronomer, Father Secchi, having shown to the Pope some of his (Brunetti's) anatomical preparations illustrative of his researches on the means of preserving animal structures.

Chromic Acid in Therapeutics.—In the *Bulletin Général de la Thérapeutique*, Dr. E. Magitot recommends *chromic acid* as an application to various affections of the buccal mucous membrane—such as all forms of stomatitis; and particularly the different kinds of gingivitis, from that connected with dentition (as when, for example, it attends the eruption of a wisdom tooth), to ulcerative stomatitis. Aphthæ, and divers other ulcerations of the buccal mucous membrane, are also, he says, rapidly modified by this agent. But the affection for which he specially recommends the acid is "alveolo-dental osteo-periostitis."

METALLURGY, MINERALOGY, AND MINING.

The Physical Properties of Gadolinite.—According to the researches of M. Des Cloizeaux, the mono-refracting crystals of this mineral (which is named after M. Gadolin, a Russian chemist) ought to be referred to the epidote. The percentage composition of the Gadolinite from Ytterby is, according to Dr. Berlin's analysis, quoted by the author—Silica, 25·62; oxide of yttrium, 50·00; oxide of cerium, 7·90; protoxide of iron, 14·44; lime, 30·00; magnesia, 0·54; alumina, 0·48; potassa, 0·19; soda, 0·18. Total, 100·65.—Vide *Comptes-Rendus*, May 10.

Aluminium a Bell-metal.—Some Belgian manufacturer has just had a bell cast of aluminium, and, we [*Scientific Opinion*] are informed, with very good results. It is of course extremely light, so that, though large, it can be easily tolled. Its tone is said to be loud, and of excellent pitch.

The Manufacture of Copperas.—The following is a brief statement of an improvement in the process for applying copperas to the purification of coal-gas, devised by Mr. P. Spence. "My invention consists in the production of copperas from compounds of iron in a proto state by treatment with sulphuric acid. The substance I prefer is the slag of puddling-furnaces, commonly called tap cinder, or the slag which results from regulus during the process of smelting copper ores, but other proto compounds in a native state, or arising from manufactures, may be employed, of the former of which I give as examples the Cleveland and blackband ironstones. These substances having been ground, are treated in an ordinary manner with sulphuric acid in a suitable vessel, and the result is copperas in a dry powdery condition, applicable to the purification of gas from ammonia, or to other ordinary manufacturing purposes in which copperas is required. If it be desired to produce the usual copperas of commerce, it may be obtained by dissolving the dry powdery mass in an ordinary manner, and then crystallising it, as usually practised in such processes."—Vide *Mining Journal*, May 15.

Utilisation of Blast Furnace Slag.—The following method is now adopted in several iron works in Belgium:—The slag is allowed to run direct from the furnace into pits about eight or nine feet in diameter at the top, with sides sloping inwards towards the centre, where they are about three feet deep. The mass is left for eight or nine days to cool, when a hard, compact, crystalline stone is obtained which is quarried and used for building purposes, but chiefly for paving stones. They appear to wear exceedingly

well, being quite equal to the grits and sandstones already so much used.—Vide *The Artisan.*

Coal from Sea-weed.—Some time since, says the *Annales du Génie Civil,* the practice was introduced of converting marine algæ by calcination into an excellent coal superior to ordinary wood charcoal for filtering water, disinfecting sinks, polishing glass and correcting the acidity and decolorising wines,—also for precipitating and decolorising vegetable alkaloids. Until recently no value was attributed to the marine algæ—to-day they are an important article of commerce in several islands.

The colours seen in tempering Steel.—An article in one of the American journals on the tempering of steel, states that the process is guided by the colour, and gives the following summary of the tints observed:—1. Being put upon burning fuel, the steel gradually heated becomes tarnished, yellow, and *straw-yellow.* 2. The heat increasing, the colour deepens, and reaches a gold yellow, *full yellow.* 3. Afterwards, the steel takes several shades, rapidly following and blending with each other; they are purple, pigeon's throat, copper, *brown yellow.* 4. These shades become deeper until they become *violet.* 5. Afterwards they pass rapidly to indigo blue, *full blue, dark blue.* 6. This colour becomes weaker, and gives a *sky-blue* more or less pure. 7. The blue takes a greenish tint and produces shades which are grey and *sea-green.* 8. At last the steel *reddens,* and will no longer give distinct colours. The shades of these eight colours, which are called tempering colours, are perfectly distinct, very apparent, and easy to recognise; but they take place only after hardening and on clean steel. The metal which has not been hardened will not show these colours so plainly; the shades are mingled, blended, and less in number.—Vide *Van Nostrand's Engineering Magazine,* No. III.

Failure of a proposed Plan for Armour Plates.—Armour plates, made by coiling bars of iron as for Armstrong gun tubes, welding the coil by upsetting, cutting the coil in two, and flattening out the halves into plates, have, says one of the metallurgical journals, proved a great failure, as the experts prophesied. The welds were found very defective.

How to Weld Copper.—The difficulty of welding copper due to the formation of an infusible oxide, has been, says the *Mining Journal,* overcome by a device of Mr. P. Rust, Inspector of Salt Mines in Bavaria. The use of microcosmic salt on the surfaces to be united succeeded perfectly, but was too expensive; he, therefore, substituted a mixture of one part of the salt with two parts of boracic acid, which answered the same purpose as the original compound, with the exception that the slag formed was not quite as fusible as before. This welding powder should be strewn on the surface of the copper at a red heat; the pieces should then be heated up to a full cherry-red or yellow heat, and brought immediately under the hammer, when they may be as readily welded as iron itself. For instance, it is possible to weld together a small rod of copper which has been broken; the ends should be bevelled, laid on one another, seized by a pair of tongs, and placed together with the latter in the fire and heated; the welding powder should then be strewn on the ends, which, after a further heating, may be welded so soundly as to bend and stretch as if they had never been broken. Mr. Rust has welded strips of copper plate, and drawn them into a rod

without difficulty. To ensure success, the greatest care must be taken that no charcoal or other solid carbon comes into contact with the points to be welded, as otherwise phosphide of copper would be formed, which would cover the surface of the copper, and effectually prevent a weld. In this case it is only by careful treatment in an oxidising fire and plentiful application of the welding powder that the copper can again be welded. It is, therefore, advisable to heat the copper in a gas flame. As copper is a much softer metal than iron—it is much softer at the required heat than the latter at its welding heat—it must be carefully hammered with a very light hammer, or better, by a mallet, and so shaped as to resist the blows as far as possible.—Vide *Mining Journal*, May 15.

The Minerals of the Breitenbach Meteorite.—The *Proceedings of the Royal Society* for May contain a report of Professor Maskelyne on this subject. This meteorite, which belongs to the rare class intermediate between meteoric irons or siderites and meteoric stones or aërolites (a class to which I applied some years since the term siderolites), was found in Breitenbach, in Bohemia. It is a spongy metallic mass, very similar to the siderolite of Rittersgrün, in Saxony, the hollows in the iron being filled by a mixture of crystalline minerals. These minerals seem to consist almost entirely of two; and the present notice deals with these two minerals. 1. One of them is of a pale green colour, crystallising in the prismatic system, and presenting at once the formula of an augitic mineral and a crystalline form nearly approximating to that of olivine. 2. The other mineral is one of very great interest. It is, in short, silica crystallised as tridymite. In bulk it forms about a third part of the mixed crystalline mass. The crystals are very imperfect; but measurements in those zones accord with those of an hexagonal crystal. A section made for examination in the microscope showed two small crystals in which the axis happened to be normal to the section. Light traverses these crystals with equal brilliancy during the rotation of the crystal between crossed Nicol prisms. That this was due to gyratory polarisation, and of a right-handed kind, was shown in the following manner:—A comparative experiment was made with two sections of quartz of opposite qualities, and of the requisite thickness to give the "sensitive tint" with crossed Nicols; and below these were placed two thin sections of right and left gyrating quartz, giving an orange tint. The two minute microscopic sections gave, on comparison of the colours in the centre of the field in each case, unmistakable evidence that the gyration was similar to that of "right-handed" quartz. There can be no doubt from these results, further details of which are to be laid before the society, that this mineral is silica in the form of its opaloid crystal, to which Von Rath has given the name of Tridymite.

Detection of Phosphorus in Cast Iron.—M. Tanten, a French metallurgist, who has given much attention to this important problem, makes the following remarks:—It is well known that very small quantities of phosphorus produce no sensible alteration in the quality of cast iron, whereas if the proportion exceeds a few thousandth parts the iron is robbed of its most essential qualities. It is very important, therefore, to ascertain the exact amount of phosphorus present. Nearly all the methods in use for this purpose consist in treating the iron by means of oxidising agents, so as to cause the phos-

phorus to pass into the condition of phosphoric acid, which is precipitated in the state of a magnesian compound. Several causes of error exist in this treatment, for—1. A part of the phosphorus escapes the action of the agents, and disengages itself in the form of an hydrogenous compound. 2. It is necessary to act upon very diluted solutions to prevent the ammoniacal-magnesian phosphate mixing with the oxide of iron, in which case it is difficult to collect the small amount of phosphate deposited on the sides of the vessel in which the precipitate is made. 3. The arsenic which may be contained in the iron enters into the magnesian precipitate in the form of arseniate as insoluble as the phosphate.

Creosote oil as a Source of Heat.—We have it on the authority of our contemporary, the *Journal of the Society of Arts*, that Mr. W. D. Dorsett has brought out a system by which not the creosote oil but its distilled vapour, which is more powerful, is made to do the work of coal in heating iron plates to the heat necessary for bending them for ships' armour-plating and other similar purposes, where the advantages sought are a very high and at the same time so equal a temperature as that, while producing the required amount of ductility in the material to be operated upon, it shall not be deteriorated in its fibrous tenacity. For some two or three months Mr. Dorsett has been experimenting with his patent fuel in Woolwich Dockyard, and so satisfactorily to the Admiralty authorities, that they have instituted tests at Chatham, with a view to the preparation of the armour-plating of the *Sultan* armour-plated ship now building in that dockyard. The advantages may thus be shortly summed up as compared with coal:—A greatly diminished cost and saving of time in producing the required heat of iron, as well as a saving of labour; an absence of refuse, and a surface altogether free from scale. As regards the effect of this new mode of heating upon the metal itself, one of the dockyard operatives declared, somewhat emphatically, that the commonest iron treated by it came out of the furnace as good as the best Low Moor. The apparatus is simple, and inexpensively applicable to existing coal-furnaces. It consists of a reservoir, from which the oil is pumped up as wanted into a receiver, where, by the application of heat, the vapour is generated, and this is passed through pipes into the furnace, and used as fuel in the ordinary way.

MICROSCOPY.

The Microscopical Work of the Quarter.—The existence of the *Monthly Microscopical Journal* so stimulates histological inquiry that the brief space we are enabled to give to the subject does not admit of a thorough record. For the benefit of those who can specially devote their attention to this subject, we give the titles of the papers which have appeared in the last three numbers of the *Monthly Microscopical Journal*:—

April.—Notes on the Scale-bearing Poduræ. By S. J. McIntyre, F.R.M.S.—On the Fibres of the Crystalline Lens of Petromyzonini. With a Note on the Æsophagus of the Aye-Aye. By George Gulliver, F.R.S.—Two New Forms of Selenite Stages. By Frederick

Blankley, F.R.M.S.—Researches on the Constitution and Development of the Ovarian Egg of the Sacculinæ. By M. J. Gerbe.—On the Simple Structure of Compound Leaves. By W. R. McNab, M.D., Edin. —On the Microscopical Structure of some Precious Stones. By H. C. Sorby, F.R.S., &c.—On the Construction of Object-glasses for the Microscope. By F. H. Wenham.—On the Rhizopoda as embodying the Primordial Type of Animal Life. By G. C. Wallich, M.D., F.L.S., &c.—On the Structure of the Red Blood Corpuscle of Oviparous Vertebrata. By William S. Savory, F.R.S.—A Small Zoophyte Trough. By W. P. Marshall, President of the Birmingham Natural History and Microscopical Society.—On the Preparation of Rock Sections for Microscopic Examination. By David Forbes, F.R.S., &c.—On the Markings on the Pleurosigma angulatum and on the Lepisma saccharina. By J. B. Dancer, F.R.A.S.

May.—Notes on Zoosperms of Crustacea. By Alfred Sanders, M.R.C.S., F.R.M.S.—Protoplasm and Living Matter. By Dr. Lionel S. Beale, F.R.S., Fellow of the Royal College of Physicians, Physician to King's College Hospital, and lately Professor of Physiology and of General and Morbid Anatomy in King's College, London.—On some New Infusoria from the Victoria Docks. By Wm. S. Kent, F.R.M.S. —Professor Owen on Article VI., No. III., of the 'Monthly Microscopical Journal.'—On the Construction of Object-glasses for the Microscope. By F. H. Wenham.—Description of Parkeria and Loftusia, two Gigantic Types of Arenaceous Foraminifera. By Dr. Carpenter, V.P.R.S., and H. B. Brady, F.L.S.—The Microscope in Silkworm Cultivation. By M. Cornalia.

June.—On the Proboscis of the Blow Fly. By W. T. Suffolk, F.R.M.S. —Note on the Blood Vessel System of the Retina of the Hedgehog. By J. W. Hulke, F.R.S.—On Crystals Enclosed in Blowpipe Beads. By H. C. Sorby, F.R.S., &c.—A New Process of Preparing Specimens of Filamentous Algæ for the Microscope. By A. M. Edwards.—Action of Anæsthetics on the Blood Corpuscles. By J. H. McQuillen, M.D., D.D.S., Professor of Physiology in Philadelphia.—A New Universal Mounting and Dissecting Microscope. By W. P. Marshall, President of the Birmingham Natural History and Microscopical Society.—On the Construction of Object-glasses for the Microscope. By F. H. Wenham.—On Free Swimming Amœbas. By J. G. Tatem, Esq.

The Binocular Spectrum Microscope.—This instrument, which was described a few nights since at the Royal Society by Mr. Crookes, and which was favourably spoken of by Dr. Carpenter, is made by Mr. Charles Collins, of Great Titchfield Street, W. The principal features are the sub-stage and the box of prisms. The former carries a sliding-plate to hold the slit and apertures, a spring stop and screws for adjusting them, and a reversed object-glass. The slit and this object-glass are about two inches apart, and if reflected light is passed along the axis of the instrument, the object-glass forms a very small image of the slit in front of it. A milled head moves the whole sub-stage, and screws bring the image of the slit to any part of

the field. Beneath the slit is an arrangement for holding an object of irregular surface or dense substance. The stage has a concentric movement, so as to permit the object to rotate, and enable the image of the slit to pass through it in any direction. The direct-vision prisms consist of three flint and two crown, fitted in a box screwed into the end of the microscope. By means of a pin they are thrown in or out of action. The object-glass screws on in front of the prism-box. By taking the illumination from the sky or a white cloud, Fraünhofer's lines are visible, and by direct sunlight they are seen in great perfection; the dispersion is sufficient to cause the spectrum to cover the whole field, and the achromatism of the lenses being nearly perfect, the lines from B to G are practically in the same focus. A double-image prism near the slit enables two spectra to be seen, oppositely polarised, and the variations in the absorption lines are at once visible. A Nicol's prism as polariser, and another as analyser, can be connected, and these enable the brilliant colours shown by some crystalline bodies, when seen by polarised light, to be examined.

PHOTOGRAPHY.

Cracking of Negatives.—The cracking of the thin film of collodion which forms the negative is a source of annoyance and loss to many photographers, and there are few artists of much experience who have been wholly exempt from it. A few weeks ago this subject was revived at a meeting of the London Photographic Society by a lady whose name is well and favourably known in connection with the artistic development of photography, Mrs. Julia Cameron, who had discovered that a large number of her best negatives had their films seriously damaged by means of a delicate network of cracks. This evil, although serious, is easily prevented and its effects equally easily cured. Dampness of the atmosphere is generally understood to cause the reticulated crackings; hence, to prevent the atmosphere from having any effect of this kind, the negatives, when not in use, should be kept in packets separated from each other by means of one or more layers of blotting-paper. When thus packed and wrapped round with paper sized or varnished, so as to be comparatively waterproof, it may be safely assumed that the negatives will never crack in the manner described. A plate-box of the usual form is objectionable on account of each plate being exposed to the action of the atmosphere by which it is surrounded. When a negative has already become cracked, a soft pad of cotton wool should be charged with some fine lamp-black, and rubbed all over its surface. The crackings are thus filled up so as to render their previous existence incapable of being detected. Whatever may be thought of the soundness of the principle of this remedial measure, there can be no doubt whatever as to its excellence in actual practice.

The Morphine Process.—An American photographer, in experimenting with morphia as a preservative agent for dry plates, has found that by means of the following preparation, which keeps well, plates may be prepared that will yield fine negatives for many months after they are made. Mix toge-

ther:—hot water, 6 oz.; pulverised sugar of milk, ¼ oz.; tannin, 40 grs.; tincture of opium, ½ drm. These are added to the water in the above order. The sugar of milk should be dissolved and allowed to stand half an hour before being filtered, after which the other ingredients are to be added.

Photo-statistics.—At a recent meeting of the French Photographic Society, a suggestion was made concerning the desirability of organising plans for obtaining authentic photographic statistics, such as the quantity of silver and other chemicals consumed, the number of photographers in each country, the value of their productions, &c., &c.

A Cloud Diaphragm.—From time to time suggestions have been made for effecting the uniform lighting of the negatives in a lateral direction, for it is a recognised fact that the intensity of the light on the centre of a photograph is greater than that by which the margins are produced. This, however, is scarcely noticeable except in the case of pictures containing a very wide angle. In a stop or diaphragm for a landscape lens it is desirable that a peculiar adjustment be made, so as to reduce the intensity of the light on the sky of the picture, and increase in a corresponding degree that required on the comparatively dark foreground. A very ingenious method of effecting this was proposed by the Rev. William Read, of Manchester, and consists in placing the diaphragm, not at a right angle to the axis of the lens as is usually done, but obliquely, and in such a manner as to transmit a much wider pencil of light from the foreground of the scene to be photographed than from the sky. By this contrivance the bright sky is not "overdone," and represented as a flat white mass, as is so commonly the case. The tendency to darkness of the foreground in the photograph is also provided against. The perfecting this idea has of late engaged the attention of opticians, and it is expected that before long an improved cloud-stop on this principle will be an article of commerce.

New Photographic Society.—A photographic society has been formed in Bristol, under the presidency of the Bishop of Gloucester and Bristol. There are many clever amateur and professional photographers who reside in Bristol and its vicinity; hence there is no reason why the society should not rapidly attain a high position.

New Method of Preparing Printing Surfaces.—Mr. Davies, an Edinburgh amateur photographer, has completed some experiments, instituted by him with a view to render common papers sufficiently hard on the surface to bear being floated on the sensitising solution without absorbing it. As a consequence, he is now able to produce brilliant photographs on such apparently unsuitable surfaces as those of brown wrapping paper, the backs of handbills, drawing-paper, canvas, &c. Several good photographs, some executed on cartridge paper, have recently been exhibited at one of the London societies, as an illustration of what the process is capable of doing. The method of preparing the paper is as follows:—From four to six grains of gelatine are soaked in an ounce of water for an hour, and are then dissolved by the application of heat. While still warm, add slowly, and with constant stirring, from four to five drachms of a solution of white lac. The strength of the lac solution should be six ounces of methylate spirits of wine to one ounce of either white or orange lac, according to the colour of the surface to which it is to be applied. The mixture of the gelatine and solution of lac pro-

duces a creamy-looking emulsion, in which is dissolved four grains of chloride of sodium, or a like equivalent of any other chloride that may be preferred. This solution, after being filtered, is applied to the paper by means of a large flat camel's hair brush, and when dry it is ready for being sensitised by nitrate of silver in the usual way.

New Photo-enamel Process.—M. De Luey-Fossarieu, a Parisian artist, has just published a new method of producing vitrified, or enamel photographs. A plate of glass is coated with a sensitive solution composed of borax, white sugar, gum arabic, honey and bichromate of ammonia, dissolved in water. When dry, the plate is exposed to light, under a soft transparent position; the development being effected by brushing on suitable pigments in very fine powder. This adheres to the surface inversely in proportion to the action of the light. The film, being transferred to the enamelled tablet, is vitrified in a suitable muffle.

PHYSICS.

Electric Phosphorescence in Rarefied Gases.—In a recent communication to the French Academy (May 10), M. Le Roux states that these phenomena are not alone produced by the passage of the electric spark through gases, but can be caused by a process of induction. When, he says, a cog-wheel, highly electrified, is set in rapid motion close to a tube containing a rarefied gas, phosphorescent phenomena exhibit themselves.

The Phosphorescence seen in Rarified Gases after the Passage of the Electric Spark.—This subject, which is one of great interest, has been inquired into by M. Edouard Sarasin. Instead of a tube he uses a bell-glass for the vacuum. After describing the general arrangements, the author observes:—The gases experimented on in this apparatus were, first, oxygen and its compounds, and then other gases containing no oxygen. Oxygen, the author states, always gave a persistent luminosity after the interruption of the current. In order to see it, he says, it is necessary to close one's eyes while the current is passing; then, on opening the eyes when the current has ceased, "one sees a sort of pale light along the track of the spark," or rather that the spark had previously traversed. At low pressures, that is to say at 3 mm. and lower, this light fills the bell-glass. It is at a pressure of 2 mm. that the maximum of intensity and duration is produced. No other simple gas gives the same results. Hydrogen, nitrogen, chlorine, and iodine vapours give not the least trace of phosphorescence. The compound gases which contain no oxygen likewise give no luminosity of this kind. Thus ammonia, coal-gas, and hydrochloric acid gas, give none. And the same may, to a great extent, be said of atmospheric air, notwithstanding the oxygen that it contains. On the other hand, the compounds of oxygen all possess this property, more or less, and some of them in a very high degree. The substance which produces the most intense effect is sulphuric acid. In experimenting on the vapours of sulphuric acid, the author simply places under the bell-glass a large capsule filled with the concentrated Nordhausen acid. Then, when the air is exhausted, the vapour of the acid rises and

diffuses itself throughout the space. Some of the experiments with this substance were of great interest. When nitrogen, air, nitrous oxide, carbonic acid, and carbonic oxide were used, the luminosity was in each case produced; but when hydrogen was employed, not the slightest appreciable effect was obtained. M. Sarasin gives the following hypothetical explanation of these phenomena:—The nascent oxygen or ozone is diffused throughout the space. In this state it has a very strong tendency to combine with the elements in its presence, and in fact up to the time that the current ceases it recombines with them. This recombination of nascent oxygen or ozone, being effected with great energy, must be accompanied with a considerable degree of heat, and this in its turn produces the luminosity to which the term phosphorescence is given.—*Comptes-Rendus*, April 12.

A new Battery for Telegraphic purposes, but which may perhaps be generally useful, has been invented by M. Guyot, and apparently is not unlike the ordinary Menotti sand battery. It consists of a porous earthen vessel filled with finely-powdered iron ore, in which is plunged a cylinder of gas-retort charcoal and an ordinary vessel filled with concentrated solution of common salt, in which is placed a slip of zinc. The only care required to keep such a battery in order is to keep the latter vessel always full of concentrated solution. Further the solution may be replaced by sand impregnated with it, or by salt in crystals, the humidity of the atmosphere being always sufficient to serve as a solvent.

The Physics of the Gulf Stream.—M. James Croll, who has published some papers on this subject, speculates thus as to the stream as a heat-carrying medium. The total quantity of water, he says, conveyed by this stream is probably equal to that of a stream 50 miles broad and 1,000 feet deep, flowing at the rate of four miles an hour. And the mean temperature of the entire mass of moving waters is not under 65° at the moment of leaving the Gulf. I think we are warranted to conclude that the Gulf Stream, before it returns from its northern journey, is on an average cooled down to at least 40°, consequently it loses 25° of heat. Each cubic foot of water, therefore, in this case carries from the tropics for distribution upwards of 1,500 units of heats, or 1,158,000 foot-pounds. According to the above estimate of the size and velocity of the stream, 5,575,680,000,000 cubic feet of water are conveyed from the Gulf per hour, or 133,816,320,000,000 cubic feet daily. Consequently, the total quantity of heat transferred from the equatorial regions per day by the stream amounts to 154,959,300,000,000,000,000 foot-pounds. From observations made by Sir John Herschel and by M. Pouillet on the direct heat of the sun, it is found that were no heat absorbed by the atmosphere, about 83 foot-pounds per second would fall upon a square foot of surface placed at right angles to the sun's rays. Mr. Meech estimates that the quantity of heat cut off by the atmosphere is equal to about 22 per cent. of the total amount received from the sun. M. Pouillet estimates the loss at 24 per cent. Taking the former estimate, 64·74 foot-pounds per second will therefore be the quantity of heat falling on a square foot of the earth's surface when the sun is in the zenith. And were the sun to remain stationary in the zenith for twelve hours, 2,796,768 foot-pounds would fall upon the surface.

The Temperature of the Air, and that of Trees and Forests.—In a paper sent in to the French Academy on March 29, M. Becquerel gave an account of some curious inquiries recently conducted by him on this point. He stated that in severe cold in winter, when the temperature falls to 8°, 10°, and further below zero, it is colder in woods than outside them. M. Becquerel the elder has taken this question up again, with the aid of observations which he made in 1858 and 1859 with the electric thermometer on the temperature of the air in the north, compared to that of a tree of 0m. 45 in diameter, to 0m. 22 below the bark. In the month of July, at the time of the greatest heats, the temperature in the air was successively at 29·40, 28·20, 26·95, &c.; whilst in the tree on the same days the register was 24·60, 25·90, 25·40, &c.; the differences were equal to 4·80, 2·30, and 1·55, always diminishing. Once the temperature of the air, at the end of several days, reached 18·78; that of the tree was, on the contrary, higher, as follows:—24·65, 23·50, 21·50. These results show that a certain time is necessary for the heat to penetrate the tree, but without attaining the maximum temperature of the air, except in certain peculiar circumstances already set forth. The observations recorded further show that in summer the temperature of the air is in general higher at nine o'clock at night than at nine o'clock in the morning, and even frequently higher than at three o'clock. This is a proof that the maxima only occur rather late in the evening.

A new Oxyhydrogen Lamp.—*Les Mondes* (May 6) gives an account of some experiments which are given nightly at Paris in illustration of the qualities of a new lamp. The burner, which is arranged to burn either pure hydrogen gas or coal gas at any pressure from two millimetres up to several centimetres, is constructed in the following manner:—The oxygen issues from a central opening; the hydrogen or coal gas issues from small tubular openings not unlike those met with in the Leslie gas-burner; but instead of being as in that burner almost vertical, they are in this instance bent so as to lay almost horizontal, and thus stand with the openings opposite to each other, while the oxygen is in the centre; the flame is directed against a piece of zircon-magnesia. We further notice a circular Argand burner without any magnesia cone, and so arranged as to have the combustion of the gas supported by oxygen gas instead of by air. A modification of this burner, as regards the arrangement of the supply tubes, is made to serve for burning gas fed by oxygen, the burner being placed in strong glass globes so as to suit the purposes of lighting mines and for submarine lamps. Care has been taken by proper and suitable means to carry off the products of the combustion in each case in such manner as to insure the safe use of the apparatus.

ZOOLOGY AND COMPARATIVE ANATOMY.

The Mole Cricket.—Those who are interested in this group will be glad to learn that Mr. S. Scudder, the well-known American entomologist, has written a very valuable memoir on these insects. It is published by the

press of the Essex Institute, from which has issued Dr. Packard's excellent work noticed in our last number.

A larva and beetle of the Elater genus have, says the *Athenæum* (June), been recently brought from Bahia and exhibited at the British Museum. The following description of them has been given. When seen in the da;ʼ ght it is somewhat like a meal-worm, but more tapering at each end and rather more than an inch long, of a pale yellow colour, with a small red head. There are ten beautiful bright golden and green luminous spots on each side of the body, edging the stigmata and differing in brilliancy as the animal respires, the head emitting a most brilliant ruby light, like the lamp of a railway locomotive. The insect often lies on its side, forming a ring of beautiful lamps, with the ruby head in the centre. When the animal crawls in the dark it looks like a double line of yellow lamps, as it were following the ruby light. The light is much more brilliant and intense than that of the glow-worm, but the individual spots are smaller.

Natural History at the British Museum.—In the "Report" just presented to Parliament, Prof. Owen reports in general for the Departments of Natural History, progress in arranging and improving the exhibited collections. He complains, as before, of want of room; the additions numbering 35,552.—Dr. Gray details for the Department of Zoology the acquisition of 24,144 specimens, of which 17,144 are Annulosa; the printing of catalogues of Diurnal Lepidoptera, by Mr. A. G. Butler; and of Heteropterous Hemiptera, Part III., by Mr. F. Walker; also many important items of the additions.—The Department of Geology, under Mr. Waterhouse, has been employed in new arrangements.—The Department of Mineralogy, under Dr. Maskelyne, has acquired 1,036 specimens, including diamonds. Dr. Maskelyne has also added largely to the collection of meteorites, a subject in which he is now engaged in elaborate researches.

Life on the deep-sea Bottom.—The Americans continue their important dredging enquiries in the Gulf Stream. A recent number of the *Bulletin of the Museum of Comparative Zoology* (No. 7) gives the second series of reports of results. Mr. L. F. Pourtales, who supplies the record, states that the utmost depth reached with the dredge was 517 fathoms, or 3,102 feet, or over 1,000 feet beyond the late researches near Spitzbergen. The bottom has been divided into three regions, extending in zones around the Florida reefs:—1. From the reef outwards four or five miles to the depth of 90 fathoms; 2. From 90 to 250 or 350 fathoms; 3. The bottom of the channel, which does not much exceed 500 fathoms. The first region is barren, and covered only by dead and broken shells, showing that the fauna of the reef itself does not extend seaward. The second is "rich in animal forms," and is particularly interesting to the geologist. It is a limestone, gradually increasing by the accumulation of the calcareous remains of Corals, Echinoderms, and Mollusks. These débris are consolidated by the tubes of Serpulæ, the interstices filled up by Foraminiferæ, and smoothed over by the Nullipores. It is supposed that this will eventually thicken until the water is shallow enough for the Astreans and Madrepores to begin their work of founding a new barrier similar to the existing reefs. This limestone is filled with recent fossils, furnished in great part by the animals now living on the bottom, but a few contribute by sinking after death from the higher regions

of the superincumbent water (teeth of fishes and shells of Pteropods), and others are brought by currents from littoral regions (bones of the Manatee, and fragments of littoral plants). All the branches of the animal kingdom, so far as their marine carnivorous orders are concerned, are abundantly represented in this region, but it is destitute of plants. The third region is sparsely inhabited by a few Mollusks, Radiates, and Crustaceans, but the peculiar animals are the microscopical Globigerinæ whose siliceous shells have covered the bottom of the channel with a thick deposit. The deep-sea animals of the second and third regions are of smaller size than allied forms of the littoral zone. The only exception is an Echinus, which is nearly of the average size, and an Actinia.

The American Lepidoptera.—The American Entomological Society is now issuing in parts a list of Butterflies and Moths. The editors are Messrs. Grote and Robinson.

American Grasshoppers have been equally well dealt with in a catalogue prepared by Mr. Samuel Scudder.

The Vascular parts of the Retina of the Hedgehog.—The *Proceedings of the Royal Society*, May, contains a communication by Mr. J. W. Hulke, in continuation of his former papers on the structure of the retina. The chief peculiarity, he says, is that *only* capillaries enter the retina. The vasa centralia pierce the optic nerve in the sclerotic canal, and, passing forwards through the lamina cribrosa, divide at the bottom of a relatively large and deep pit in the centre of the intraocular disc of the nerve, into a variable number of primary branches, from three to six. These primary divisions quickly subdivide, furnishing many large arteries and veins, which, radiating on all sides from the nerve-entrance towards the ora retinæ, appear to the observer's unaided eye as strongly projecting ridges upon the inner surface of the retina. When vertical sections parallel to and across the direction of these ridges are examined with a quarter-inch objective, it is immediately perceived that the arteries and veins lie, throughout their entire course, upon the inner surface of the membrana limitans interna retinæ, between this and the membrana hyaloidea of the vitreous humour, and that only capillaries penetrate the retina itself.

The development of the Zoosperms of Fishes forms the subject of a paper published in the *Bulletin* of the Academy of Sciences of St. Petersburg, by M. Owsiannikoff, whose researches on the zoosperms of the salmon and other fishes lead him to conclusions quite opposed to those of Kölliker. The cells which develop the zoosperms may, he says, sometimes be seen to contain from ten to fifteen secondary cells within them, and these are the young spermatozoa. The nucleus of the cell becomes the head, and the protoplasm which surrounds it forms the tail. The adult spermatozoon has a head like "an ace of hearts," pointed in front and broad behind. It consists of two lateral parts, which are separated by a superficial groove. Immediately behind the head there is a thickening of the tail, which however has no special feature. The zoosperm does not move along by jerks, but by a distinct undulating motion. When water is added to the seminal fluid the zoosperms move about briskly, but when much is added the tails disappear. This, the author says, is due to a retraction of the tail towards the head, and a coiling of the former round the latter.

The teeth of Rotifera.—The Rev. Lord Sidney Godolphin Osborne made a communication on this subject to the Literary and Philosophical Society of Manchester at its meeting on April 6. The dental organ, he says, consists primarily of two slightly arcuate jaws, broad at their upper extremities and narrow and pointed at their lower ones. Elastic ligaments bind these together at each end. The front or convex margin of each jaw is crenulated, the projections corresponding with the transverse parallel ridges usually regarded as the teeth of the animal. These jaws form the two lips of a sac, the lateral parts of which consist of a separate tissue, which overlaps each jaw at its anterior margin, hooked on, as it were, to the crenulations and thrown by them into permanent parallel corrugations. Each of these corrugated organs passes first outwards and then downwards and backwards, where they are bound together by another broad membrane, which completes the sac posteriorly. The food enters this sac by a passage from the œsophagus, at its superior extremity, is crushed between the two jaws, and then passes out again by a similar orifice at its opposite or lower end to enter the stomach. Of these tissues the jaws are the hardest, and are capable of being dissected out, as Lord S. G. Osborne has succeeded in doing. The lateral corrugated organs have a concavo-convex form, which they appear capable of retaining after dissection; they appear less dense than the jaws, but more so than the membranous tissues of the gizzard, to which they are united. The central corrugations are always the largest.

The Varieties of Dogs.—Dr. John Edward Gray has written a paper on the varieties of dogs in the *Annals of Natural History*. In reference to that kind of variation, which he thinks ought to be looked upon as abnormality, the author points out the following four types:—1. The short and more or less bandy legs of the turnspit and lurchers, which are common to terriers and spaniels. 2. The more or less imperfect development of the upper jaw, found in the bull-dog, pug-dog, and different breeds of spaniels. 3. The great development of the ball of the eyes, so as to become too large for the orbit and exceedingly prominent and liable to accident, found in some breeds of spaniels and terriers. 4. The more or less complete want of hair, which is generally accompanied by a more or less complete want or great imperfection in the development and rooting of the teeth, showing the relation between these two organic productions.

The Conformation of the Negro Cranium.—At the meeting of the Physical Society of Edinburgh, on April 7, a paper was communicated by Dr. J. S. Smith and Professor Turner, on eight negro crania, recently sent from Old Calabar. Four of the skulls were those of males and four females. They were the crania of slaves of the Calabar negroes, and were probably of the Iboe tribe, having been brought from the delta of the mighty Niger or Quorra. These negroes have been described as being among the most degraded of the negro race. The skulls, however, showed no such appearance of degradation, and one of the male skulls had an internal capacity or brain bulk of 93 cubic inches. The crania also exhibited a much greater variety of size than was to have been expected in a rude negro people. Mr. Robb considers that the degraded state of the delta negroes has been much exaggerated. He has lived among them, and states that they are simply what paganism makes them, but their nature is similar to our own, and they

can be elevated to a higher platform. Minute details were given of their anatomical character and measurements, and the gronp of crania are to be added to the valuable collections of the Anatomical Museum of the University.

The Atlantic Sea-bottom.—On June 5, the *Porcupine*, then in charge of Mr. J. Gwyn Jeffreys, put into Galway Harbour, and news was received of some of the results. These are briefly stated in a note in a weekly contemporary. The weather had been fine, and dredgings had been made at depths from 80 to 808 fathoms. Soundings, too, have been taken in places where previous soundings were few. The 808 fathom dredging, which took 1,200 fathoms of line, brought up two hundredweight of Atlantic mud. The "winding in" of this find occupied an hour, the donkey-engine doing its work to full satisfaction. In a haul at 110 fathoms 408 large specimens of *Echinus Norvegicus*, and a living mollusk, with eyes, were brought up. But in addition to natural history, the expedition has demonstrated that a new kind of thermometer for indicating the temperature at any depth gives satisfactory results. If this thermometer is trustworthy, then all previous thermometers used in deep-sea soundings are wrong, for at the 808 fathoms depth it showed four degrees lower than the thermometer usually employed, and the same at 723 fathoms. And further, Mr. W. L. Carpenter, who is with the expedition, writes concerning the experiments on water taken at different depths, that the bottom water does not appear to differ from surface water in the *quantity* of contained gases, nor in specific gravity; the latter at 60° F. being always 1·0278. But the proportions of oxygen to carbonic acid and nitrogen differ greatly, for bottom water contains from two to three times more carbonic acid than surface water. And as regards the tests for organic matter in the water, there is an almost total absence of decomposing organic matter; but of matter in a condition ready to decompose there is a nearly constant quantity whether at bottom or surface.

The Organ-pipe Coral.—Dr. Perceval Wright, Professor of Botany in Trinity College, Dublin, states as the result of his observations on this Cœlenterate that the details given in Kölliker's *Icones* are in some respects incorrect.—*Annals of Nat. Hist.*, May.

The British Nemerteans.—The structure and arrangement of these animals have been stated in a paper read before the Royal Society of Edinburgh, but only published in abstract in its *Proceedings*. The anatomy is minutely gone into, and forty new species are described.

The Danger of Microscopic "Methods."—M. Robinski, in a memoir published in the *Comptes-Rendus* for April, calls attention to the errors in interpreting structure caused by using reagents. He alleges that the lymphatics which Herr Recklinghausen has discovered in the epithelium are mostly the result (artificial) of the use of nitrate of silver, which stains the outside of the cells more than the inside and thus leads to the notion of the existence of a number of communicating canals which are really not present at all.

A new Siliceous Sponge which was taken at Santa Cruz, and which has been examined by Dr. Leray, an American naturalist, is described at considerable length in the *Monthly Microscopical Journal* for June. The genus *Pheronema* has been founded for its reception, and it is said to resemble

Hyalonema. The following details are given. The body of the sponge is oblong ovoidal, with the narrower end upward, and with one side more prominent than the other. The lower extremity is rather cylindroid and rounded truncate. The upper extremity is conical, with a truncate apex presenting a large circular orifice. This is about four lines in diameter, and is the exit of a canal which descends in the axis of the sponge for almost half its depth, and then appears to divide into several branches. The sides of the sponge form thick dense walls to the cylindrical canal, which is of uniform diameter before its division. In its present condition the sponge is of a light-brown hue. Its surface exhibits an intricate interlacement of stellate, siliceous spiculæ, including a tissue of finer spiculæ of the same character, the whole associated by the dried remains of the softer sponge tissues. More or less fine sand, especially at the lower end of the sponge, appears to be introduced as an element of structure. From the lower end of the sponge there projects a number of distinct or separate tufts of siliceous spiculæ, looking like tufts of blonde human hair. In the specimen there are fifteen tufts projecting around two-thirds of the extremity of the sponge, but the remaining third of the extremity of the latter exhibits about ten orifices, from which as many additional tufts appear to have been extracted. Length of the body of the sponge 4¼ inches; diameter at middle 22 lines, at lower end 15 and 17 lines, at upper end 8 lines. Length of tufts of spiculæ 2 inches.

The Mammalia of North-West America.—Some notes on these were recently furnished in a paper read by Mr. Robert Brown before one of the Scottish societies. The author gave an account, illustrated by maps, of the different district faunas into which he divided the extensive territory of North-West America, and detailed the various genera and species belonging to each. Special reference was made to species believed to be new. Mr. Brown gave many curious and interesting details of his own experiences and adventures in the wilder districts of that comparatively little known part of the world. The paper was, we believe, one of a series which Mr. Brown is preparing on the zoology and botany of North-West America.

The Chair of Physiology at the Royal Institution.—The Fullerian Professorship, which was lately resigned by Professor Huxley, has been given to Dr. Michael Foster.

Comparative Psychology is the title of the new section to be formed in the Ethnological Society.

The Desiccation of Rotifers.—The Proceedings of the *Literary and Philosophical Society* contain a report by Professor Williamson on some observations on this questionable phenomenon by Lord Osborne. Professor Williamson exhibited some small glass tanks or Rotiferous aquaria, some of which had been prepared by Lord S. G. Osborne, which had been dried up again and again. One of these, in a dry state as it had been for five months, was moistened by the addition of a little water, and in five minutes the animals were in full activity, looking thin and hungry, but perfectly vigorous. The experiments of Lord S. G. Osborne confirm the statements of Spallanzani, that these Rotifers may be dried up for years without vitality being destroyed. Tanks for the preservation and examination of these objects are readily made by joining two ordinary microscopic glasses on three sides by means of electric cement, and then stocked by the introduction of a little

Rotiferous dust. In such tanks they multiply rapidly, the occasional addition of a few drops of water to counteract evaporation being all that is needed for their preservation.

Function of the Contractile Vesicle in Infusoria.—In a paper on *Stentor,* in the last *Journal of Anatomy,* Dr. Moxon brings forward some new arguments on this point. He denies that such organisms, from their small size, require a heart.

The Proboscis of the Blow-fly.—The *Monthly Microscopical Journal* for June contains four very handsome plates, illustrating this very peculiar organ. Microscopists will do well to refer to them.

Free-swimming Amœbæ.—The above number also contains an account by Mr. J. G. Tatem of certain curious tailed swimming amœbæ.

A new Genus of Salamanders has been found by Professor Cope (U.S.) in a number of specimens brought from Mexico. It differs from *Sperlerpes,* in having the parietal and palatine bones unossified, and the inner nares opening into the orbits. The phenygoid teeth are in one patch. Toes, four on the front feet and five on the hind, rudimentary. The tail is as long as the head and body together. The total length is only two inches. It has a pale dorsal band and black sides. A female specimen contained eggs one line in diameter. He has called the species, which is a new generic type, *Thorius pennatribus.*

Origin of the second Cervical Vertebra.—We learn from the *American Naturalist* (June) that a very important memoir on this subject has been published in a recent number of the Proceedings of the Swedish Academy, by Professor Kinberg. This origin he refers to the fusion of two vertebræ together. In mammalia, generally, says Dr. Lutken, who reports upon it, the odontoid process is separated, during a longer or shorter period, from the true *corpus epistrophæi* by two intervertebral epiphyses in the same manner as in all other ordinary distinct vertebræ; the odontoid process has parts answering to the arms, which are, however, not developed into true arches, but analogous to that of certain caudal vertebræ; the epistrophæus has of course two corpora fused together like the sacral vertebræ, and consequently draws its origin from the connection of two primordial vertebræ.

The Zoological Society has been doing excellent work during the quarter. It would be impossible, with the space at our disposal, to give even a list of the papers read. We may, however, refer to one of great importance to comparative anatomists. It was upon the homologies of the bones of the internal ear, by Professor Huxley.

The Chair of Comparative Anatomy in the College of Surgeons.—*Scientific Opinion* announces that Professor Huxley has resigned the chair, and that Mr. W. H. Flower, F.R.S., is likely to succeed him. We regret Professor Huxley's resignation, but at the same time congratulate the Council of the College on its selection of Mr. Flower for the Hunterian chair.

The Muscles of Invertebrate Animals.—On this subject a very elaborate paper appears in the last number of *Max Schultze's Archiv für Mikroskopische Anatomie,* by Herr Schwalbe. The author goes through several types, beginning with the Actinia, and ending with Echinoderms and Gasteropods. Two handsome folding plates illustrate the memoir, and represent the muscular fibres as prepared with chromic acid, bichromate of potash, and osmic acid, and seen with a No. 10 Hartnack's immersion lens. The fibres of some

of the annelids (like Nereis) are peculiar in possessing a number of lateral processes. In others the sarcolemma is indicated, though it may of course be asked in how far it is a post-mortem or artificial structure, or how far it is represented by the connective tissue which unites the muscular fibres together.

Cohesion of the Blood-Corpuscles.—As to this singular phenomenon, Professor Norris, of Birmingham, gives the following account in a paper quite recently communicated to the Royal Society. "My idea of the blood-corpuscle is that its contents are something essentially different, so far as cohesive attraction is concerned, from the liquor sanguinis, that is to say, not readily miscible with liquor sanguinis. This is of course self-evident, if, according to some modern views, we regard the corpuscles "as tiny lumps of a uniformly viscous matter," inasmuch as such matter must be insoluble in, and immiscible with, the liquor sanguinis. The explanation is equally easy, if we accept the old and, I believe, the true view of the vesicular character of these bodies, as we have only to assume that the envelope is so saturated with the corpuscular contents as practically to act as such contents would themselves act, *i.e.* to exhibit a greater cohesive attraction for their own particles than for those of the contiguous liquid. The cohesive power of the blood-corpuscles varies with varying conditions of the liquor sanguinis, and this is doubtless due to the law of osmosis; for we can readily imagine that when the exosmotic tendency was in excess the corpuscles would become more adhesive, and, on the contrary, when the endosmotic current prevailed, less so. In any case the increased cohesiveness will be due to the increased extrusion upon the surface of the corpuscular contents. All, then, that is required in the case of the blood-corpuscles is a difference between their liquid contents and the plasma in which they are submerged. That this difference is not so great as between the liquids used in these experiments is probable, but it must also be remembered that the attraction is not so powerful. The power required to attach the blood-corpuscles together is, on account of their exceeding minuteness, extremely small, as they are thus so much more removed from the influence of gravitation, and brought under that of molecular attraction."

The Colouring Matter of the Feathers of the Turaco.—This substance, which has been especially examined by Professor Church, is thus described by him in the *Proceedings of the Royal Society*. It is a remarkable red pigment, extracted from four species of Turaco, or plantain-eater; it occurs in about fifteen of the primary and secondary pinion feathers of the birds in question, and may be extracted by a dilute alkaline solution, and reprecipitated without change by an acid. It is distinguished from all other natural pigments, yet isolated by the presence of 5·9 per cent. of copper, which cannot be removed without the destruction of the colouring-matter itself. The spectrum of turacine shows two black absorption-bands, similar to those of scarlet cruorine; turacine, however, differs from cruorine in many particulars. It exhibits great constancy of composition, even when derived from different genera and species of plantain-eater; as, for example, the *Musophaga violacea*, the *Corythaix albo-cristata*, and the *C. porphyreolopha*.

The Chair of Physiology at Bartholomew's Hospital, lately vacated by Mr. W. S. Savory, F.R.S., has been given to Mr. Morrant Baker.

POPULAR SCIENCE REVIEW.

CONTENTS.—No. XXXIII.

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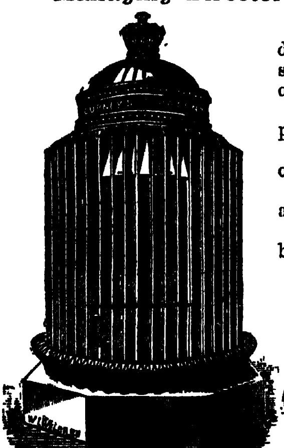

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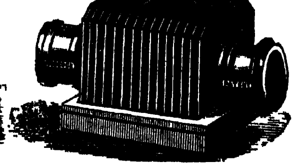

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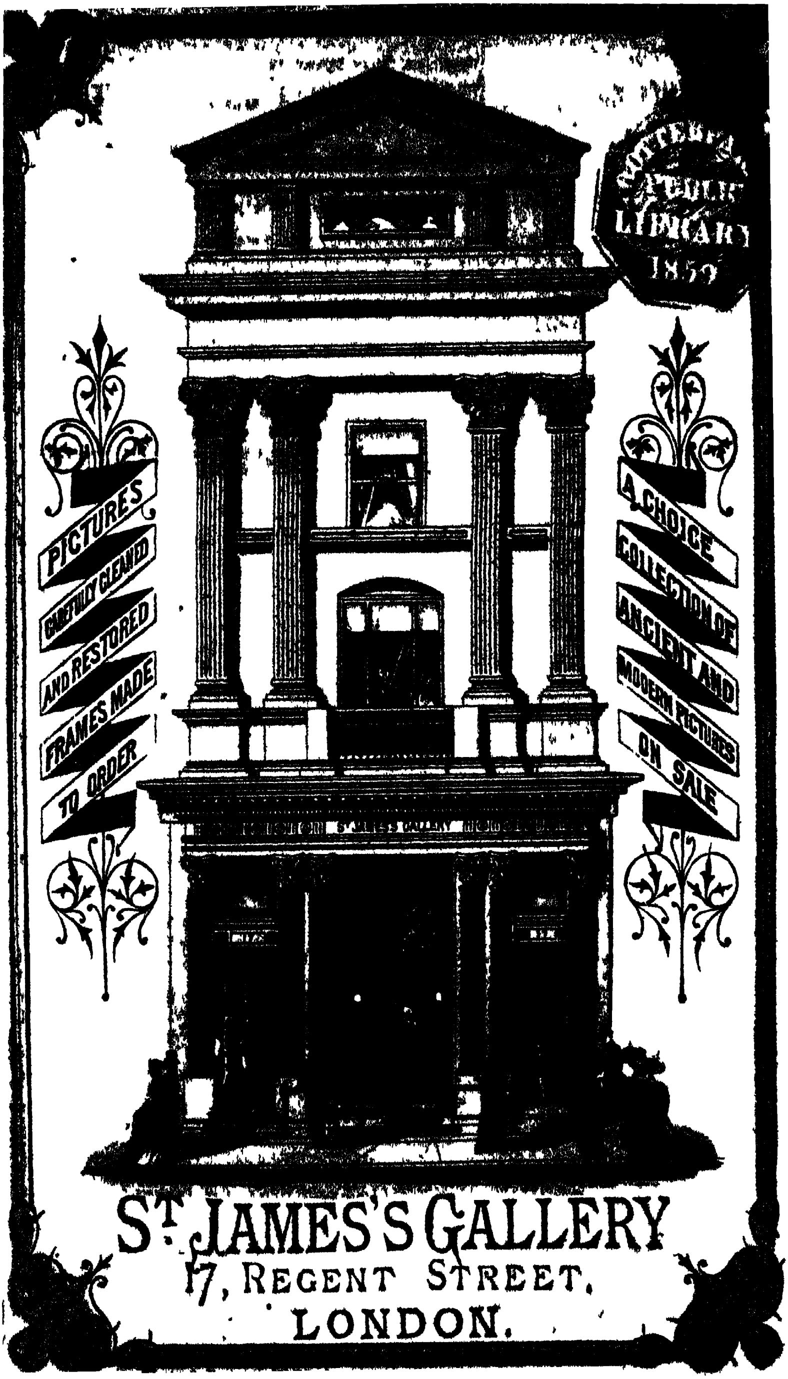
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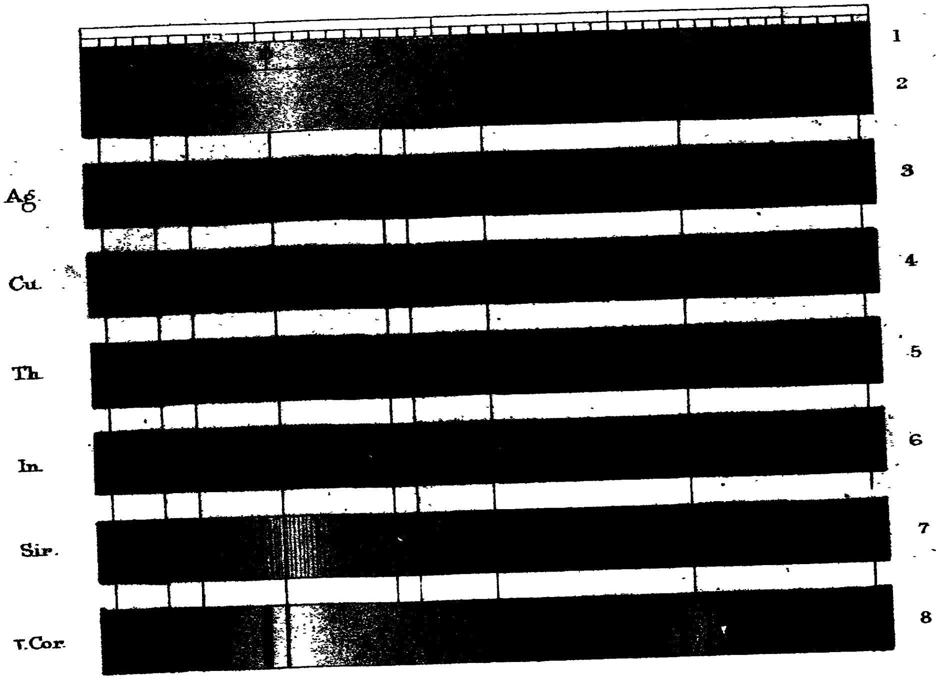
Plate L.



W West lith

Spectra of certain metals and Heavenly Bodies.

EXPERIMENTAL ILLUSTRATIONS OF THE MODES OF DETERMINING THE COMPOSITION OF THE SUN AND OTHER HEAVENLY BODIES BY THE SPECTRUM.

A Lecture delivered to the Working Men of Exeter, August 21, 1869. By WM. ALLEN MILLER, M.D., D.C.L., V.P.R.S.

[PLATE L.]

ONE of the most important features of the age in which we live is the rapid manner in which man's knowledge of the powers and properties of the different substances around him is being extended. We behold, on all sides, an extraordinary growth of what is called *physical science*, and we witness everywhere the increasing command which this increased knowledge gives to man over the materials of which this globe consists.

I shall devote the time which we are to spend together this evening to an illustration of some of the modes in which this mastery of mind over matter is to be obtained; and in this review shall draw my examples mainly from the striking achievements recently performed in the application of optics to chemistry, usually described under the term of *spectrum analysis.*

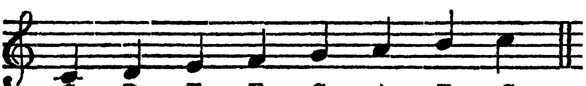
Marvellous as are many of the revelations of science, it is to be noted that the methods of their discovery may generally be resolved into the application of ordinary observation to the objects to be examined. The distinction between ordinary and scientific observation is, indeed, merely in the degree of its accuracy. The man of science is perpetually contriving means to render his observations strictly accurate, and to reduce them, whenever it is practicable, to a form in which their results may be represented by weight or by measure.

To take a simple instance: There is, perhaps, no great difficulty, even to those unfamiliar with science, in believing that sound is produced by the vibratory motions of the sounding body transmitted through the air to the ear; since when a harp-string is suddenly stretched, or the cord of a piano is struck, a tremulous motion of the string is seen to accompany the sound thus produced; and as the motion becomes less visible the sound gradually dies away. It is not difficult to render these

motions distinctly visible to a large audience, as I intend presently to show. What, now, is the exact distinction between a mere noise and a musical note—between harmony and discord? A noise consists of the recurrence of sounding vibrations at irregular intervals; whilst every musical note is produced by its own particular number of vibrations, which recur at perfectly equal intervals. Several contrivances exist, by means of which the number of these vibrations, which occur in a second of time, can be counted. It has been thus ascertained that the higher or shriller the note, the more frequent are the motions by which it is produced. A simple expedient will enable us to show the number of vibrations of a note—say the treble C of the piano, and to prove that this note is due to twice as many vibrations in a second as are necessary to form the middle C, or the octave immediately below it.

Here are two tuning-forks, one of which, when caused to vibrate, emits a note which is an octave higher than the other. Attached to one of the prongs of each fork is a needle which partakes of the motions of the prong. If a piece of smoked glass be drawn across the points of the needles when the forks are not sounding, the soot will be scratched off the surface of the glass in the form of two straight lines, the image of which may be thrown upon the screen by means of a strong light. But if the tuning-forks be made to sound by drawing a violin bow across them, a second piece of smoked glass will then show not two straight, but two zigzag lines; and the line produced by the shriller note will exhibit just twice as many notches as that caused by the other fork. In a similar manner, it might be shown that the intermediate notes are produced by vibrations of intermediate frequency, a definite number being required for each note, as may be seen in the table, which exhibits an octave of the musical scale.

RATIO OF THE SOUNDS OF THE MUSICAL SCALE.



C	D	E	F	G	A	B	C
1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	2

	Vibrations per Second.	Intervals.
C	256	
D	288	32
E	320	32
F	341$\frac{1}{3}$	21$\frac{1}{3}$
G	384	42$\frac{2}{3}$
A	426$\frac{2}{3}$	42$\frac{2}{3}$
B	480	53$\frac{1}{3}$
C	512	32

The curves produced by two notes sounded at the same moment may fit into each other at certain definite intervals. In such a case we have a harmonious combination; whereas, when the curves do not so fit, a discordant combination of sounds is the result. The annexed woodcut exhibits the curves produced

by the notes of a common chord, the upper and lower curves representing those of the octave. The vibrations of a tuning-fork, or other sounding body, are transmitted to the ear through the air, which is thrown also into wavelike movements, the waves of sound being longer in the lower, and shorter in the shriller notes. In the treble C of the piano, which is produced by 512 vibrations per second, the waves that it occasions in the air are 2ft. long; while in the C of the octave below, the number of vibrations is 256, or just half, and the length of the aërial wave is 4ft., or twice as great.

The effects produced by vibration are not limited to those of sound. The still more remarkable phenomena of light and heat are connected with movements of this kind of intense rapidity, the frequency of which is so great as almost to baffle belief, from 35,000 to 70,000 such waves being contained in the space of a single inch in the case of light.

It has been concluded from experiments, into a description of which time does not permit us to enter, that in all substances which give out light of their own—such as a piece of lime intensely heated in a jet of burning gas, or a rod of charcoal glowing in the extreme heat produced by a current of electricity excited in a powerful voltaic battery, the particles of the solid are in a state of inconceivably rapid vibration, and that these vibrations are transmitted to the eye by means of some infinitely subtle medium, termed the ether, which fills all space and the interstices of matter, and which, though not light itself, when thrown into vibration by a luminous object, excites in our eyes the sensation of light; just as the air, though not itself sound, yet, when thrown into vibration by a sounding body, excites in our ears the sensation of sound.

I will now, by means of the voltaic battery, ignite a piece of charcoal very intensely. The light thus produced will occasion a series of intensely rapid vibrations in the portion of the ether contained in this room, and these will pass off in straight lines in

all directions from the white-hot charcoal. If the charcoal be enclosed in a dark lantern, I can allow a portion only of its light to escape into the room, and can direct it at pleasure into any part by using a small mirror or flat polished surface. The opening by which the light escapes is, in this instance, a narrow vertical slit. You will observe the light is of a pure white.

I propose now to show you another property of light, and to prove that white light consists of a mixture of several different colours. If the slice of light which issues from the lamp be allowed to fall upon a clear plate of glass with flat faces parallel to each other, the light will pass through the glass without undergoing any apparent change either in its colour or its direction; but if it be allowed to fall upon one of the faces of a piece of glass cut into the form of a triangular bar or prism, we shall have a very different result. The light will be abruptly altered in its direction as it passes through the glass; it will be refracted, as it is said: and now the beam of light, instead of falling upon the screen as a slice of white light, will be spread out into a ribbon of gorgeous tints, the brilliant hues of which will graduate insensibly from red into violet. This is represented in fig. 2 of the Plate. The red end of the beam of light which is least altered from its original direction is said to be the least refrangible; whilst the violet, which has experienced the greatest change, is said to possess the greatest amount of refrangibility. As this word "refrangibility" is one which I shall often have to use, it is necessary that you should distinctly understand what it means—viz. the degree to which any ray is suddenly bent from its original direction by the action of the prism.

Such a coloured image constitutes what Sir Isaac Newton called the prismatic spectrum. He varied this experiment in a great number of ways, and concluded that white light consists of a mixture of various colours, like those of the rainbow. By recombining these colours, the original white light is reproduced. This may be done by sending it through a second prism placed in the opposite direction to the first. The action of the prism which we have just examined is to open out the colours of which the white light consists into a fan of coloured light; so that, instead of perceiving a single white image of the slit, a series of images is obtained of every shade of colour. Each image possesses its own special degree of refrangibility, and its characteristic tint; whilst each overlaps its neighbour on either side, so that the whole forms a continuous and beautiful blending of harmonious hues, commencing with red and ending in the violet. What the pitch of a note is in sound, such is colour in light. The undulations of the ether are longest and slowest in the red, and shortest and most rapid in the violet,

with all degrees of intermediate frequency between. We may say that red is the bass, and violet the treble of colours.

Few things in the progress of science are more remarkable than the manner in which discoveries in one branch of enquiry often prove of the greatest importance to the advancement of other branches of knowledge, with which they appear, at first, to have no connection. A striking instance of this kind occurs in the manner in which optical science has aided the studies of the chemist. By means of chemical analysis, it has been discovered that the various substances which are found upon the earth may be separated into a comparatively small number of bodies, out of which no other kind of matter may be separated. Out of sulphur, for example, nothing but sulphur can be obtained. These the chemist terms *elements*, and out of these all the different substances with which we are familiar are formed. For instance, the air we breathe is composed mainly of a mixture of two such elementary bodies—viz. the gases oxygen and nitrogen; water consists of oxygen chemically united with the gaseous element hydrogen; and among the elements are the various metals—gold, silver, iron, copper, magnesium, sodium, and so on. These different substances the chemist distinguishes from one another by means of certain chemical tests. For instance, I may, by the addition of ammonia to a certain solution, find copper by the beautiful blue tinge produced. In like manner, I may, by the white cloud occasioned on adding common salt to a second vessel, ascertain the presence of silver; while in a third, the presence of iron is not less certainly revealed by the red colour produced on adding potassic sulphocyanide. Within the last few years optics has come to the aid of chemistry in a manner which I must now endeavour to explain.

We have seen that this spectrum of glowing charcoal is continuous from end to end. Provided that the ignited material be a solid, its chemical nature has no influence upon the colour of the light which it emits. Whether, for example, the heated body consist of lime, magnesia, flint, clay, charcoal, iron, or platinum, so long as the substance is in the solid form a *continuous* spectrum is obtained, containing rays of every degree of refrangibility, and of every colour, from the deepest red to the extreme violet. The spectrum of an ignited cloud of solid particles, such as that produced by soot or any solid suspended matter, such as phosphoric anhydride when phosphorus is burned in oxygen gas, is also continuous. The same continuous spectrum is also produced by a white-hot liquid, such as melted copper or cast iron, and no difference dependent upon the chemical nature of the substance can be perceived in any of these cases. Such spectra, therefore, teach us nothing of the

chemical composition of the bodies by which they are produced.

But the case is very different when the spectrum of a gaseous body is examined. Then we have an *interrupted* spectrum, composed of bright lines of light of certain colours only, with intervals between them more or less completely dark. Whenever an interrupted spectrum composed of bright lines is seen, we infer that we are dealing with the spectrum of a transparent gaseous body in a state of intense glowing heat. Each gas or vapour emits light of a particular kind, which is collected into a line or group of lines peculiar to itself. If the position of these lines be accurately measured, it is found that the same substance always gives rise to lines which occur invariably, exactly in the same part of the spectrum. Hence these lines may be made use of as tests of the particular substance by which they are produced. I showed you, just now, chemical tests of silver, copper, and iron. Now let us look at the optical tests, which are not less certain. Silver, for example, when heated sufficiently to distil it in vapour, emits a brilliant green light, which is mainly concentrated into two intense green bands, fig. 3, the other part of the spectrum being produced by the charcoal on which the silver rests. Copper also emits a green light, but this is seen to consist of a more complex system of bright bands, fig. 4. Iron, when volatilised at a still higher heat, in like manner gives a light with a system of bands still more complicated and numerous. Magnesium likewise furnishes an intense green band, which is really composed of three, so closely approaching each other as to appear on the screen but one. Each metal and each chemical element has in fact its own special set of bands. Each, when converted into vapour, vibrates in a definite way, producing a special set of luminous vibrations of fixed frequency, just as when a particular tuning-fork is struck, it occasions a series of waves of sound which occur with the particular frequency characteristic of its peculiar musical note. If, therefore, we can determine with accuracy the position and number of lines in the spectrum of each chemical element, we can at once recognise its presence whenever we see its light, by simply measuring the position of these lines.

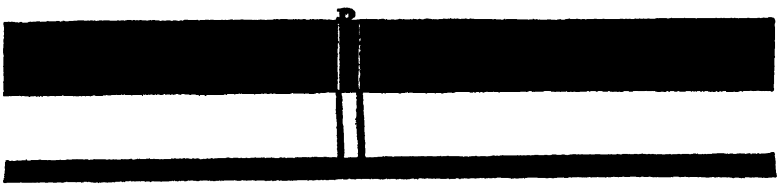
Why, then, does a substance, when in the solid or the liquid form, not produce a spectrum like that which it furnishes in the gaseous state? Bodies, when in a solid or liquid form, are tied together by the attraction of their particles, and consequently their vibrations appear to be those of the mass, not those of their constituent atoms; whereas, in the state of gas or vapour, their constituent particles are widely separated from each other, and each is free to move independently of the rest.

You will now easily perceive that this optical method of ana-

lysis enlarges the field of our enquiries to an extent which is really incalculable. Not merely can we, by looking through a prism into flame in the midst of this room, ascertain that silver or iron, or both, are there. If I were to carry my apparatus to the top of Haldon Hill whilst you remained below, you would still be able to recognise the metal, be it what it might, which I was distilling in the voltaic arc. Nay, more, look into a furnace at any distance that you please through a prism, you may interpret the chemical changes that are occurring within its flame; and the same method of observation may be extended to the outburst of a volcano, or beyond the limits of the earth, to the light of the sun, to the faint beams of the stars, and to the almost imperceptible haze of the nebulæ studded here and there through the boundless fields of space.

Do not, however, suppose that the foregoing observations comprise all that is needful to enable you to interpret all these wonders. Up to the present time I have shown you two kinds of spectra, viz., 1. the *continuous* spectrum, characteristic of the light of a glowing solid, or liquid, or cloud consisting of glowing solid particles (see Plate L., fig. 2), and 2. the *interrupted* spectrum, composed of the bright lines which distinguish the spectra of glowing gases or transparent vapours (fig. 3). 3. Besides these there is a third kind of spectrum more remarkable than either, consisting of a luminous coloured band crossed by *black lines*, shown in fig. 1. If an intensely luminous solid be viewed through a gas less intensely heated a very singular result is obtained. The spectrum of the gas is seen, as well as that of the solid behind it; but the gaseous spectrum is reversed, that is to say, the lines of which it is formed, instead of being bright, are *black*, as is shown in the lower half of fig. 9; while in the upper half the bright lines of sodium are seen occupying exactly the same position as that occupied by the dark lines

FIG. 9.



below, the lower part showing the appearance of a compound spectrum, formed by a luminous solid, in front of which is an atmosphere of sodium vapours. These effects you will see may be imitated experimentally, and the result may be shown on the screen.

How are these black lines produced by thus adding light to light? Instances are not wanting in which sound added to

sound produces silence, the waves interfering and neutralising each other. But the disappearance of light in these black lines is not due to this cause. In the case of these black lines it arises from the circumstance that a body which is emitting light consisting of vibrations of a definite degree of frequency, can absorb those portions of the light of other bodies which possess a corresponding rate of vibration, and can then radiate it forth anew in all directions; much in the same way as a tuning-fork produces a resonance when held opposite the mouth of a box holding a column of air of such length as to vibrate in unison with itself, though it produces no such resonance when held opposite a box of different length which does not vibrate in harmony with it. The air in the resounding box first absorbs and then gives forth the vibrations of the fork with which it corresponds.

In the case of sodium, for instance, the vapour of this metal absorbs the light of that particular portion of the spectrum of the body behind it, which corresponds with it in its rate of vibration, and it allows all the rest of the light behind to pass on unaffected.

If the sodium vapour is at a considerably lower temperature than the body behind, the absorbed rays will elevate the temperature of the metallic vapour somewhat, and will cause the sodium to give out a light which is a little greater than that due to the sodium alone; but it is considerably less than that which would be produced by the continuous spectrum of the body behind it, and the result is that when the combined image of the two spectra is thrown upon the screen we obtain what appears to us as a black line: but it really is a line of low illuminating power, which, being contrasted with the intense light of the spectrum on either side, produces upon our eyes the impression of a black line.

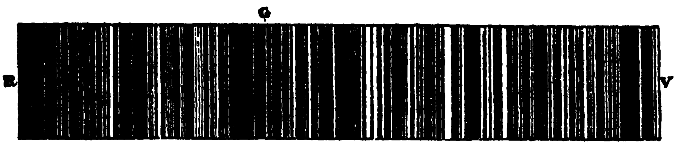
If the sodium be raised in temperature until it acquires the same degree as that of the body behind it, the light which falls upon the sodium flame will still be absorbed as before; but now, as the intensity of the sodium light is equal to that of the spectrum behind it, no sensible effect will be produced upon the screen. But if, on the other hand, the sodium flame be still hotter than the body behind it, it will be more intensely luminous, and instead of a black line we shall have a bright line crossing the spectrum at this point.

The vapour of sodium, according to its temperature, may therefore give rise to three different effects. 1. It may produce a black line, when the temperature of the sodium is low. 2. It may produce no sensible effect, in which case the temperature and the light of the sodium are equal to those of the body behind it. 3. It may produce a bright line, but in this case the

temperature of the sodium and its light must be considerably higher than those of the glowing body behind it. What is true of the vapour of sodium is true also of other vapours.

The light of the sun affords us a remarkable instance of a case in which the first condition is realised. The spectrum of the sun's light is not continuous, but is crossed by a multitude of fine black lines, a few of which are represented in fig. 1 on the Plate. These lines, you will observe, vary in number, in blackness, and in definiteness in different parts of the spectrum. A facsimile of the lines in the neighbourhood of the line marked G as photographed by Mr. Rutherfurd, is shown in fig. 10, upon a scale eight times larger than the spectra shown in the coloured plate.

FIG. 10.



The fact of the existence of these lines was first noticed between sixty and seventy years ago, by Dr. Wollaston, and anyone may easily observe a few of the principal lines by proceeding as he did; placing himself in a darkened room, allowing a beam of daylight to come in through a chink of about a twentieth of an inch wide, like that formed by the edge of a nearly closed door, and then at a distance of 10 ft. or 12 ft. viewing this line of light through a glass prism held close to the eye, with its edge parallel to the line of light. Little, however, was it imagined when these lines were first seen that in them lay the means of ascertaining the chemical components of the sun. Many among you, from what I have already said, will, however, see how this knowledge is obtainable.

The sun itself is not a mere globe of glowing iron. It consists of a central, intensely heated nucleus, above which is an atmosphere filled apparently with white-hot solid particles distributed in the form of vast clouds over the whole surface, and outside this powerfully luminous atmosphere is another less heated gaseous stratum containing the vapours of a variety of bodies, most of them metallic in their nature.

The black lines which we see in the solar spectrum are the effects produced by these cooler but still intensely heated metallic vapours, upon the light emitted by the cloud-like luminous surface of the sun.

How are we to learn what the bodies are in the sun by which these black lines are formed? The first thing to be done is to measure their position accurately, and to make a map of them.

Fraunhofer, a working optician, of Munich, was the first person who attempted this, and they have been called Fraunhofer's lines. In order to do this, he viewed the sun's light through a prism placed in the focus of a small telescope provided with micrometer screws for measurement, and he mapped upwards of 600 of them, and indicated the most conspicuous by the letters of the alphabet.

Still, this does not explain the meaning of the particular lines. The map itself needs interpretation. For this explanation, and for the mode of experiment required, we are indebted to Professor Kirchhoff. The figure shows a diagram of this arrangement in plan. If we take two wires of any metal, such, for instance, as magnesium, and by means of a strong heat, such as that of the electric spark, convert a portion of the metal into a luminous gas, and place the spark-giver at *m* opposite the slit *o* of Fraunhofer's apparatus, which, in its present improved form,

FIG. 11.

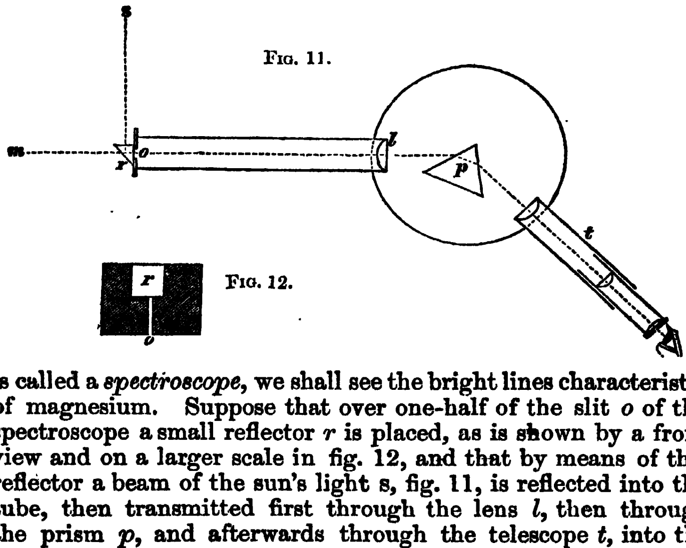


FIG. 12.

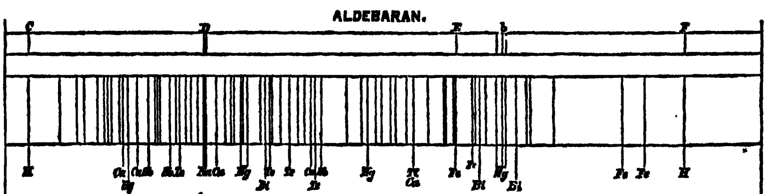
is called a *spectroscope*, we shall see the bright lines characteristic of magnesium. Suppose that over one-half of the slit *o* of the spectroscope a small reflector *r* is placed, as is shown by a front view and on a larger scale in fig. 12, and that by means of this reflector a beam of the sun's light s, fig. 11, is reflected into the tube, then transmitted first through the lens *l*, then through the prism *p*, and afterwards through the telescope *t*, into the eye of the observer, and at the same time the electric sparks are made to pass between the magnesium wires: two spectra will then be seen, one over the other, edge to edge, just as is represented in fig. 9.

By thus comparing the spectra of the different elementary bodies with that of the sun, not only was magnesium found to be present, inasmuch as the bright lines of magnesium coincide with certain dark lines in the solar spectrum, but sodium, iron, calcium, hydrogen, and eleven other elements—sixteen in all,

as enumerated in the following table, are present in the atmosphere of the sun, viz.: Aluminum, barium, cadmium, calcium, chromium, cobalt, copper, hydrogen, iron, magnesium, manganese, nickel, sodium, strontium, titanium, zinc.

By concentrating the light of the brightest fixed stars with a powerful telescope, a point of light of sufficient intensity may be obtained to enable its spectrum to be examined. It is necessary first to open out this point into a narrow line of light; and this is effected by the use of a cylindrical lens, which spreads the light out in one plane only. The telescope must be made to follow exactly the apparent motion of the star in the heavens; and in the telescope, exactly at the focus of the object-glass, a narrow slit, not wider than a fine hair, is placed. The light of the star must be kept perfectly steady on this slit, and then be examined through a small spectroscope, which is attached to the telescope and follows its movements. A special apparatus is also connected with the instrument for producing sparks from the particular metals which it is desired to compare with the lines in the star spectrum.* The diagram to which I now call your attention represents the star spectroscope employed by Mr. Huggins and myself in these difficult and fatiguing observations. Only the brighter stars have as yet been examined; eight or ten pretty fully, others less perfectly. It is, of course, impossible to render such observations visible to more than one person at a time, and then only under particularly favourable

Fig. 13.



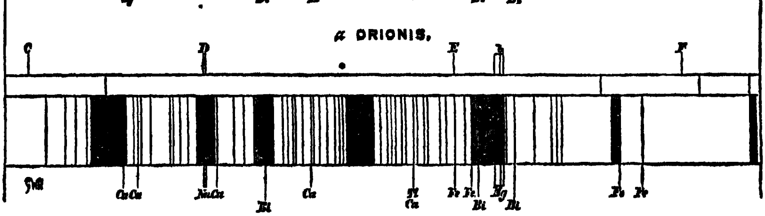


Fig. 14.

circumstances, and when the star is in a suitable position in the heavens. I have, however, here some photographs of careful

* A figure and detailed description of this instrument was given in th April number of this *Review*, p. 142, fig. 7, Plate XLII.

drawings which will give the appearance of two or three such stars. Each star has a different series of lines in its spectrum; but each is found to contain several of the chemical elements which are met with upon the earth. Fig. 13 represents the spectrum of the bright star Aldebaran, in the constellation Taurus; fig. 14 that of Betelgeus, the bright star in the shoulder of Orion, and fig. 7 on the Plate that of Sirius, the most brilliant of the stars visible to us in this country. Many of the metals found in these stars are of comparatively rare occurrence, while others are abundant. For instance, in *Aldebaran*, sodium, magnesium, calcium, iron, bismuth, hydrogen, tellurium, antimony, mercury; in *Betelgeus*, sodium, magnesium, calcium, iron, bismuth, thallium; in *Sirius*, sodium, magnesium, hydrogen, and iron.

Several of the substances found in these stars appear to be absent from our sun.

The fixed stars vary in colour, and they each have their own peculiar spectrum, yet they are formed upon a plan which these observations show is analogous to that of our sun, viz., an intensely heated nucleus or kernel surrounded by a less hot, but still prodigiously heated atmosphere, containing various metallic and other vapours, many of which are identical with the elements which occur in the earth. In the spectra, both of the sun and of the fixed stars, there are, however, numerous lines which we have not as yet been able to refer to their constituent materials. This arises, probably, in a great measure from our imperfect acquaintance with the spectra of the elements at present known. It arises in part also from our ignorance of some of the elements which compose our earth itself. Within the last eight years no fewer than four elementary bodies, viz., cæsium, rubidium, thallium, and indium have been discovered by the special character of their spectra. Thallium, for instance, produces a magnificent green line unlike that of any other element, shown at Plate L., fig. 5. Indium shows two remarkable bands in the blue, fig. 6.

Another reason why we have not yet interpreted all these lines is, probably, that many of them are the results of compounds formed in the outer and less heated part of the sun's atmosphere, where ordinary chemical attraction again exerts itself. In the intense focus of the nucleus of the sun the heat is so fierce that all chemical combinations are destroyed, and the elements occur in a state of mixture with each other, as they do in the intense heat of the voltaic arc.

But the revelations of the spectroscope do not end here. From time to time stars blaze forth in the heavens with great brilliancy, and then as speedily fade and dwindle away. Marvellous changes are seen in such cases to be going on. In

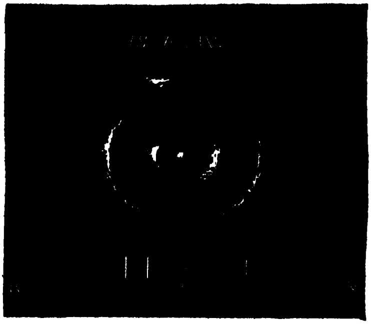
May 1866 a star suddenly burst forth in the constellation of the northern crown. On examining its spectrum, a wonderful condition of things was rendered visible, which will be made intelligible by examining a representation of the spectrum of this star—T coronæ, as it is called—Plate L., fig. 8. This star exhibits three different spectra; two of them resemble the spectra of the stars in general, consisting, that is, of the continuous spectrum of the nucleus, crossed by the spectrum of dark lines produced by the gaseous bodies contained in its outer atmosphere. But in addition to these is another spectrum, composed of four or, perhaps, five bright lines. This is the spectrum of a gaseous body in a state of intense incandescence, or glowing heat; and the position at C and F of the principal bright lines shows that one of the luminous gases is hydrogen. The great brightness of these lines shows, too, that the gas is hotter than the body of the star itself. These facts, taken in connection with the suddenness of the outburst of light, and its very rapid decline in brightness (from the second magnitude to the eighth magnitude in twelve days), that is to say, from a bright star to one invisible without the aid of the telescope, suggests the startling probability that the star had become suddenly enwrapt in the flame of hydrogen which was burning around the star and combining with some other element. As the hydrogen gradually became exhausted, the flames diminished in intensity, and the brightness of the star declined in a corresponding proportion.

I must yet mention one more of the class of objects which occur in the heavens, still more enigmatical than any which I have at present described, and upon the nature of which spectrum observations have thrown an unexpected amount of information; I mean the *nebulæ*. When the eye is aided by a telescope of moderate power, a large number of faintly luminous patches and spots are distinguished in the sky, which differ entirely in appearance from the defined brilliant points of light formed by the stars. Many of these singular objects, when viewed by the most powerful telescopes, still resemble mere shining clouds. These objects have been a standing puzzle to astronomers, and the interest connected with their nature has been increased by the suggestion of Sir W. Herschel, that they were possibly portions of the original material out of which existing suns and stars have been formed, and that probably in these nebulæ we may actually watch some of the stages through which suns and planets pass before they take their final shape.

Spectrum analysis, if it could be applied to these excessively faint objects, would immediately show whether they had a constitution like that of ordinary stars or not. Certain of these bodies when thus examined give no continuous spectrum, but

one consisting of bright lines only. Fig. 15 is copied from a drawing by Lord Rosse of a nebula, afterwards examined by Mr. Huggins, and a representation of the spectrum which he observed, and which proves that this particular nebula consists of glowing gas without any central solid or liquid nucleus.

FIG. 15.



About twenty out of sixty nebulæ examined by Mr. Huggins formed spectra composed of bright lines only. Of the rest, most give a faint continuous spectrum, as though these were really in a more advanced stage of condensation than the gaseous nebulæ. In all these spectra a bright line coincident with one of the bright lines of nitrogen occurs, so that they appear all to have a common character, and contain the same elementary substance. In a few of the brighter nebulæ, three or even four lines have been observed, as in the instance figured above; but the position of each of these lines is in all cases the same, when compared with the spectra of other nebulæ. The position of the third line coincides with that of the most prominent line in the spectrum of hydrogen, so that there can be little doubt that the elementary gases, hydrogen and nitrogen, in a state of high ignition, are the chief components of these remarkable bodies.

And now let us endeavour to form some notion of the distances of these bodies, of which the constitution and chemical nature have thus in part been made known to us.

The diameter of the earth on which we live is nearly 8,000 miles, and the moon is at about thirty times this distance from us, while the sun is 380 times as far off as the moon. How can we in any way picture to ourselves these immense distances? Suppose that the sun were represented by a globe 2 ft. in diameter, the earth would then be of the size of a pea, and it would be placed at a distance of 215 ft. from it, or about twice as far off as I am from the wall of this room in front of me; and the moon would be of the size of a mustard seed placed 7 in. from the pea, which represents the earth; whilst Neptune, the most distant of the planets, would be of the size of a large plum, and would be placed at a mile and a quarter from the 2 ft. globe supposed to represent the sun.

Well, Sirius, the brightest of the fixed stars, if measured by this scale, would be 40,000 miles away from us, or at a distance five times as great as that which now separates us in a straight

line from New Zealand. There is no doubt that many of the minute telescopic stars are several hundred times as distant from us as Sirius. Astronomical observations upon the eclipses of Jupiter's satellites have shown that it requires rather more than eight minutes for the light of the sun to reach the earth; it would take not less than twenty-three years for the light of Sirius to traverse the distance between that star and the earth if it travelled at the same rate. And of the distances of the nebulæ we have no means of forming any calculation.

How amazing the thought that throughout the whole of this unbounded range of space matter is to be found of the same kind! Aggregated into masses which, though differing from one another in composition, like the various veins of ore which occur in mines upon the surface of our globe; yet all are evidently of common origin, all obey the same laws, and all possess a chemical nature similar in kind. Surely one is tempted to think, if the discovery of such marvels, if the measurement of such distances, the estimate of the mass and the magnitude, the calculation of the velocity of these bodies in space, and the determination of their chemical composition at distances the accurate conception of which transcends even the ability of imagination; if these, I say, be not beyond the power of man, it may well be supposed that there is no limit to the discoveries which are within his reach.

In one sense this is true. The visible works of God are laid open to our investigation to an extent which is really unlimited; and one of the noblest occupations in which man can be engaged is in thus tracing the footprints of his Creator, and in discovering the laws which He has imposed upon matter, and by which suns and systems are controlled. But if there be a spiritual as well as a material universe, we must not the less have our material upon which to work, before we can attempt its investigation. It is just for the purpose of supplying this material, and of instructing us in this most important of all knowledge, that the Bible professes to have been given, since it is a knowledge which we might for ever seek in vain, in meditating on the works of creation, however successful in unveiling its secrets by scientific investigation.

While, then, we explore in admiration and delight the wonders of nature, as they are commonly termed, or the works of Him who is the author of nature, as they truly are, let none of us forget with equal diligence to study that volume which alone can reveal to us the spiritual, the unseen, and the eternal—a study which, to be effectual, must be approached in the spirit of prayer for the guidance which is promised to everyone who asks in the belief that so asking he shall receive.

WHAT IS BATHYBIUS?

By Professor W. C. WILLIAMSON, F.R.S.

DURING each successive year the Protozoa prove to be of increasing importance to the physiologist. In no other class of matured animals can the protoplasm, of which we have recently heard so much, be studied to such advantage. Constituting the lowest known manifestation of both animal and vegetable life, it seems to bring us very near to the boundary between the organic and the inorganic worlds. It exhibits the simplest phenomena of life under the least complex of conditions; hence it has recently been appealed to by one of the most philosophical of living zoologists as capable of throwing light upon the most recondite of biological problems. Without accepting all, or even the chief of the conclusions at which Professor Huxley has arrived from his study of protoplasm, he must be deemed right in the importance which he assigns to it. Whether seen as the gelatinous sarcode of the Protozoa, occupying the base of the animal kingdom, or as the yolk-material out of which the embryo of the highest vertebrate is formed;—whether we observe its plastic mass in the primordial germ of a Protococcus or of a Volvox, or as it appears in the leaf-bud of an oak, it everywhere brings before us the first stage in acts of organisation in which it is the chief, if not the only actor. Nevertheless, I am unable to see that our study of protoplasm has brought us nearer than before to a knowledge of the origin of that mysterious force which converts inorganic into organised material. There yet remains to be bridged over that unfathomed gulf which separates death from life—the most complex effects of inorganic forces from the simplest of vital phenomena. We can trace the action and development of protoplasm through successive generations of organisms, but, like the spot where the rainbow touches the ground, its mysterious origin recedes as we advance, and a weary chase leaves us no nearer our object than when we commenced its pursuit. We increase our information respecting the conditions of its existence, but not of its origin;

and I believe that from the nature of the problem this ignorance will continue.

We are asked, wherein does the so-called vital force differ from other physical forces? Oxygen and hydrogen combine to form water; if you admit vitality, why not require a principle of æquosity to explain this combination and its resultant phenomena? "What better philosophical status," asks Prof. Huxley, "has vitality than æquosity?" I reply, we require the admission of no new force to explain the combination of gases in the formation of water. The phenomena occur in accordance with known laws of affinity. The synthetical experiment is but one of a vast series of similar experiments, in each of which we can combine separate elements with absolute certainty that the resultants will be identical with, and fulfil all the functions of, the same products when formed in nature's laboratory. But the case is different when we turn to living organisms. We may know the proportions of oxygen, hydrogen, carbon, and nitrogen, existing in any form of protoplasm, and we may even succeed in forcing those elements into an artificial combination having the same proportions, but in no single instance have we been able to endow such a combination with the powers of life. The resultant is not protoplasm. It does not live. It performs none of the vital functions. "Certain conditions" are wanting, and, so far as experiment has hitherto gone, the laboratory has proved unable to supply those conditions. Some "force" is required which is not under the control of the ablest physicist, and which differs in kind as well as in degree from those with whose operations he is familiar. We infer this, because all the functions of the resultant of nature's organic synthesis are different from those of all artificial products. It is this lacking force which we indicate under the name of vital; and so long as experimental philosophers fail to make their artificial combinations do what it does, I claim to be as philosophical, and to be acting in as truly a scientific spirit, when I recognise its existence as when I speak of a magnetic force or of a force of gravitation.

Professor Huxley asks, "What justification is there, then, for the assumption of the existence in the living matter of a something which has no representative or correlation in the not living matter which gave rise to it?" Surely the question, thus put, involves a fallacy. Professor Huxley admits that to produce the results referred to the introduction of a new element is needed. The not living matter requires the aid and instrumentality of matter that is living, and it is precisely this necessity which leads me to conclude that the living matter *does* contain something wanting to the "not living matter."

The living organism increases, multiplies, and reproduces itself through a power that is inherent, whereas a crystal can only do so

through powers external to itself; whatever it may be, the vital power is always derived; no *known* combination of inorganic elements or dead forces could have created it. Except in a few obscure cases, too ill-understood to be made the basis of a grave argument, protoplasm can always be traced, directly or indirectly, to some pre-existing form of protoplasm. We nowhere discover any power which, without the intervention of some already living agent, can convert inorganic matter into living matter. If we could even trace back the history of protoplasm, until we reached one of Mr. Darwin's primæval germs, our philosophy would still leave the first of these living azotised combinations unaccounted for. Since, then, scientific experience affords no proof that life is nothing more than a function of material combinations, acted upon by physical forces, we are justified in the recognition of a vital principle, emanating primarily from a living Creator, but which, once created, appears capable of self-perpetuation to the end of time.

If, having recognised the importance of the study of protoplasm amongst the lower animals, we commence its pursuit, we soon discover the difficulties which surround it, especially when we discover the apparent inadequacy of the causes to the effects produced. We see a granular jelly evolving endlessly varied forms of grace and beauty; at one time using silica as its raw material, at another carbonate of lime. Here it glues together grains of sand, there it develops a new sand-like compound, the very nature of which has yet to be discovered. In one form it produces the horny network of a sponge—in another the ethereal tracery of an Euplectella. The colours of its products are almost as varied as their material forms. We seek the cause of all this rich diversity —but we seek in vain. We see the almost motionless granular jelly investing the objects of beauty which it has constructed, but it affords us no indication of the secret of its wondrous power.

We hail every new fact tending to throw light upon a history which is as obscure as it is marvellous. Hence the importance attached to Prof. Huxley's discovery of the vast masses of submarine protoplasm, to which he has given the name of Bathybius. When, in 1857, Capt. Dayman, of H.M.S. Cyclops, returned from his exploration of the bed of the Atlantic, some of his specimens of "soundings" were placed in the hands of Prof. Huxley for examination. The explorers had already noticed the singular stickiness of the mud brought up by the lead, and Prof. Huxley soon found that this viscid condition arose from the diffusion through it of abundance of sarcode or protoplasm of a protozoic nature. The mud, like much of what constitutes the bed of the Atlantic, consisted chiefly of accumulated shells of Globbigerna bulloides—themselves the skeletons of a protozoic sarcode. The Bathybius occurred in minute patches of gelatineus protoplasm,

usually of irregular shape, but occasionally assuming roundish forms. It consisted of a transparent jelly containing innumerable, very minute, granules, many of which Prof. Huxley found to be equally soluble in dilute acetic acid and in strong solutions of the caustic alkalies; but, in addition, there occurred some remarkable bodies to which great interest is attached. In the first instance Prof. Huxley noticed, adherent to the protoplasm, and occasionally embedded in it, numerous minute rounded bodies, soluble in acids, and to which he gave the name of Coccoliths. Still later, in addition to these Coccoliths, Dr. Wallich discovered, associated with the Bathybius, some larger spherical bodies of more complex organisation, which he designated Coccospheres. Yet more recently Prof. Huxley has re-examined his specimens under higher powers, and found his Coccoliths were of two classes—to which he now gives the respective names of Discolithus and Cyatholithus. The Discolithi he describes as "oval discoidal bodies, with a thick strongly refracting rim, and a thinner central portion, the greater part of which is occupied by a slightly opaque, as it were, cloud-patch. The contour of this patch corresponds with that of the inner edge of the rim, from which it is separated by a transparent zone. In general the Discoliths are slightly convex on one side, slightly concave on the other, and the rim is raised into a prominent ridge on the more convex side."* These objects usually range from $\frac{1}{4000}$ to $\frac{1}{5000}$ of an inch in their longest diameter.

The Cyatholiths are like minute shirt-studs. They are stated to have "an oval contour, convex upon one face, and flat or concave upon the other. Left to themselves, they lie upon one or other of these faces, and in that aspect appear to be composed of two concentric zones surrounding a central corpuscule." "A lateral view of any of these bodies shows that it is by no means the concentrically laminated concretion it at first appears to be, but that it has a very singular and, so far as I know, unique structure. Supposing it to rest upon its lower surface, it consists of a lower plate, shaped like a deep saucer or watchglass; of an upper plate, which is sometimes flat, sometimes more or less watchglass-shaped; of the oval, thick-walled, flattened corpuscule, which connects the centres of these two plates; and of an intermediate substance, which is closely connected with the under surface of the upper plate, or more or less fills up the interval between the two plates, and often has a coarsely granular margin. The upper plate always has a less diameter than the lower, and is not wider than the intermediate

* On some Organisms from great Depths in the North Atlantic Ocean. *Quarterly Journal of Microscopical Science*, Oct. 1868, p. 206.

substance."* These Cyatholithi are further stated to vary in size from $\frac{1}{6000}$ to $\frac{1}{8000}$ of an inch in diameter. The coccospheres are described by the same distinguished observer as "of two types—the one compact and the other loose in texture. The largest of the former type which I have met with measured about $\frac{1}{1300}$ of an inch in diameter. They are hollow, irregularly flattened spheroids, with a thick transparent wall, which sometimes appears laminated. In this wall a number of oval bodies, very much like the 'corpuscules' of the Cyatholiths, are set, and each of these answers to one of the flattened facets of the spheroidal wall. The corpuscules, which are about $\frac{1}{4500}$ of an inch long, are placed at tolerably equal distances, and each is surrounded by a contour-line of corresponding form." "Coccospheres of the compact type of $\frac{1}{1700}$ to $\frac{1}{2000}$ of an inch diameter occur under two forms, being sometimes mere reductions of that just described, while, in other cases, the corpuscules are round, and not more than half to a third as big, though their number does not seem to be greater. In still smaller coccospheres, the corpuscules and the contour-lines become less and less distinct and more minute, until, in the smallest which I have observed, and which is only $\frac{1}{4500}$ of an inch in diameter, they are hardly visible."

"The coccospheres of the loose type of structure run from the same minuteness up to nearly double the size of the largest of the compact type, viz., $\frac{1}{760}$ of an inch in diameter. The largest (of which I have seen only one specimen) is obviously made up of bodies resembling Cyatholiths of the largest size in all particulars except the absence of the granular zone, of which there is no trace. I could not clearly ascertain how they were held together, but a slight pressure suffices to separate them." † The relations subsisting between these Coccospheres on the one hand, and the Cyatholiths on the other, are very obscure; but Professor Huxley deems it probable that some close affinity does exist; but whether the Coccospheres have been formed from a coalescence of Cyatholiths, whether the Cyatholiths have resulted from the breaking up of the Coccospheres, or whether the Coccospheres are altogether independent structures, yet remains to be decided. There appears, however, no reason to doubt that Coccoliths, Coccospheres, and Cyatholiths, equally belong to Bathybius, as the skeleton of a sponge, or the shell of a Foraminifer belong to their respective protoplasmic sarcodes.

Since Professor Huxley completed the observations to which I have referred, Dr. Carpenter and Professor Wyville Thomp-

* On some Organisms from great Depths in the North Atlantic Ocean. *Quarterly Journal of Microscopical Science*, Oct. 1868, p. 207.

† Idem., p. 209.

son have conducted a very important series of deep-sea dredgings off the north coasts of Scotland, and in the neighbourhood of the Faroe Islands. In Captain Dayman's dredging operations the viscid mud was found between the fifteenth and forty-fifth degrees of W. longitude. Those of Drs. Carpenter and Thompson were carried on much further eastward; but in the latter instance the same deposit was found over a range of at least 200 miles, throughout which the dredge came up from time to time filled with Globigerina-mud and saturated with Bathybium, with its associated Coccoliths and Coccospheres. The Globigerina deposit exists in a similar manner in many and distant parts of the ocean, in both hemispheres; and it is more than probable that when the remote localities are subjected to the same examination as our northern seas have recently undergone, Bathybius will be found in them also. Its low organisation renders it probable that it will be found to be like its companion Globigerina, a thorough cosmopolite. On this point Dr. Carpenter suggests that the range of these objects is regulated by temperature rather than by locality. It was already known that many deep-sea localities existed, in which the Globigerina-mud did not occur; and it had even been suggested that its range was limited to that of the warm Gulf-stream. Dr. Carpenter confirms this general conclusion, and points out that its prevalence is connected with a bottom temperature of 45°, which in our northern latitudes can only be attributed to the Gulf-stream.

Bathybius yet requires to be considered in two other important relationships—the one geological and the other zoological.

Chalk, examined microscopically, has long been known to abound in minute ovate organisms, known as crystalloids, associated with the Globigerinæ and Textillariæ, of which chalk mainly consists. I recognised the organic origin of these bodies in 1847, and figured one of them very imperfectly, viewed as an opaque object, in my memoir "On some of the Microscopic Objects found in the Mud of the Levant;"* but, ignorant of Coccoliths, I concluded that they belonged to some minute form of Oolina or Lagena. More recently Mr. Sorby has subjected these bodies to a much more careful examination, and both he and Dr. Wallich have identified them with Professor Huxley's Coccoliths. It now appears that both Coccoliths, Cyatholiths, and Coccospheres, occur fossilised in the chalk, establishing, in a remarkable manner, the close resemblance of the conditions under which the chalk-beds were formed and those existing along the tract of the Gulf-stream at the present day. Dr. Carpenter goes even further than this, and regards it as "highly probable that the deposit of Globigerina-mud has been

* "Trans. Phil. Soc., Manchester," vol. viii. fig. 71.

going on over some part or other of the North Atlantic sea-bed, from the Cretaceous epoch to the present time (as there is much reason to think that it did elsewhere in anterior geological periods), this mud being not merely *a* chalk formation, but a continuation of *the* chalk formation; so that *we may be said to be still living in the cretaceous epoch.*" *

With the earlier part of the preceding paragraph I partly agree, but from its concluding sentence I must dissent. Chalk chiefly consists of an accumulation of Globigerina cretacea, *associated in almost equal proportions* with a minute Textillaria and with Coccoliths. The fossil Globigerina is probably but a mere variety of the recent G. bulloides; hence, so far as it is concerned, ancient and modern deposits may have been continuous. But in none of the modern Globigerina beds which I have examined have I found anything resembling the fossil Cretaceous Textillaria, the disappearance of which requires to be accounted for. What I believe to be the same species occurs abundantly, amongst other modern types of Foraminifera, in the recent sandy deposit underlying Boston in Lincolnshire, but I never succeeded in discovering it living in the sea. From some unknown cause it has disappeared. On the other hand, our modern deposits abound in Diatoms and Radiolariæ, of which no trace appears in the true Cretaceous beds. That in the depth of the Atlantic Cretaceous and modern deposits may be conformably and continuously superimposed is not impossible, but conformable continuity of series does not constitute identity of age or of formation. In the Speeton clay of the Yorkshire coast we have, in the same blue deposit, a transition from the Oolites to the Cretaceous beds. The *deposits* have continued to accumulate without physical change from the one age to the other, but the *formations* to which the upper and lower portions of this clay belong are distinct, and represent distinct epochs. Dr. Carpenter is disposed to conclude that the higher forms of the Atlantic and Cretaceous faunæ will prove to be nearly identical; but I doubt this, and we must not repeat the blunder of Ehrenberg, in the case of the *tertiary* beds of the Mediterranean coasts, which he regarded as Cretaceous, because he found that they abounded in Cretaceous types of Foraminifera, overlooking the wide differences presented by the higher organisations of the two formations. So in the instance under consideration. Owing to the low vitality of the Protozoa, some of them have survived the changes which time has wrought in the higher groups of animals. The recent Globigerinæ and Bathybia are probably descendants from those which lived during the Cretaceous period, but their companions are not the same. The abundant Textillariæ are replaced by Diatoms and Radiolariæ. Instead of

* "Proceedings of the Royal Society," vol. xvii. p. 192.

Marsupites we have the Rhizocrinus. The Ananchytes and Galerites are represented by Cidarites and Spatangi; amongst star-fishes Tosia (Goniaster) has given place to Ophiocoma. For the chambered Cephalopods we have the modern cuttle-fishes, whilst the Saurians and Ganoid fishes of the Cretaceous age have left no descendants in these Atlantic depths, their places being taken, in all probability, by the more familiar and much more useful codfish.

The zoological affinities of Bathybius are not very difficult to understand, though the young student is apt to become bewildered by the growing number of classifications of the Protozoa that are being offered for his acceptance, and the multitude of new terms with which, in consequence of these new classifications, our journals have become loaded. The last of these arrangements is that of Häckel, who has separated the Protozoa, under the name of Protista, equally from plants on the one hand and from animals on the other. He regards them as the common starting-point from which, in accordance with Darwinian ideas, both plants and animals have derived their origin. Without necessarily accepting this creation of a third organic kingdom, we may beneficially recognise Häckel's division of the Amæban section of the Protozoa into two groups, viz., the Monera and the Protoplasta; the former comprehending those Amæbæ which exhibit an uniform granular sarcode without any trace of or differentiation into special organs, and the latter including those types in which we have such special structures in the form of contractile vesicles, nuclei, or other differentiated appendages. So far as the structure of the sarcode is concerned, Bathybius is apparently a true Moner, and such its discoverer considers it to be. At the same time, the existence in connection with it of Coccoliths and Cyatholiths indicates the necessity for separating it from Häckel's other Monera, which have no such special appendages. But the time has not arrived for determining the absolute relations of these objects. New types, as Häckel himself admits, are being discovered, rendering modifications of his groups necessary. Meanwhile there can be no question that Bathybius is the lowest of those known Protozoa, which, like the Foraminifera, secrete calcareous elements. Remembering the extent to which the sarcode is diffused through the mud of the Atlantic, there appears much that is suggestive and important in the observation of Dr. Carpenter, that, had its power of secreting a calcareous framework been somewhat increased, so that instead of detached structures in the form of Coccoliths, &c., it had produced a continuous calcareous mass, it would have given us a living prototype of the Laurentian Eozoon. The discovery of this widely and continuously diffused Bathybius strongly sustains Dr. Carpenter in his conviction of the animal origin of that primæval structure.

ARE THERE ANY FIXED STARS?

BY RICHARD A. PROCTOR, B.A., F.R.A.S.,
AUTHOR OF "SATURN AND ITS SYSTEM," "HALFHOURS WITH THE STARS," &c. &c.

[PLATE LI.]

DURING the last few years astronomers have been attacking questions which seem, at first sight, far beyond the range of the human intellect, or of the instrumental appliances which human ingenuity can devise. A marked contrast, indeed, is to be distinguished between the inquiries which have been made within the last decade and the most valuable discoveries of all previous times. Not one of the results which had rewarded the labours of scientific men up to the middle of the present century would have seemed incredible to Francis Bacon had it been predicted to him; nay, there is scarcely one of them which is not more or less distinctly shadowed forth in that strange and little-read work of his, the "Sylva Sylvanum." But even he, daring as were his conceptions and hopeful as were his views of the powers of that method of research which he inculcated, would probably have smiled with contempt had the idea of analysing the sun or the fixed stars been mooted in his presence. The Frenchman who lately brought before the Imperial Academy at Paris the absurd proposition that our astronomers and physicists should make signals to the inhabitants of Mars and Jupiter scarcely appears a greater dreamer to us than any one would have appeared to Bacon who put forward a notion seemingly so preposterous.

At first sight it may seem to many that the subject I have now chiefly to deal with—the determination, namely, by our astronomers, of the motions of recess or approach which the fixed stars may possess—does not belong to the category of those researches which appear altogether hopeless. Yet when the true nature of the problem is understood, a different view will certainly be adopted. It will be well to look at the subject of the stellar motions in this way, to consider the difficulties which seem to

surround it on every side, and the interest which attaches to its solution, before we proceed to consider the method which has been successfully applied to one star, and will doubtless in the fulness of time be applied to hundreds, with results whose importance it is impossible to over-estimate.

The stars, it is well known, have to ordinary observers every appearance of fixity. If Hipparchus or Ptolemy could now look on the orbs they watched so lovingly in the far-off years, they would see nothing to induce them to imagine that the stars are in motion. Whether the aspect of the heavens is exactly the same now as when Aratus sang the glories of the constellations, we cannot indeed assert with any certainty of conviction. Many of the stars may shine with different lustre, some few have perhaps disappeared, and possibly some new stars have appeared upon the scene. But such changes as these are not in question at present; I refer only to apparent changes in the stars' places.

Astronomers in our day know indeed that the stars are changing their place upon the heavens. But it is not because the change of place has been made perceptible to ordinary vision; but because by means of the telescope it has become possible to magnify so largely the effects of change, that movements which would produce no perceptible effect in thousands of years if ordinary vision only were in question, are recognised as certainly as though the astronomer could see the star actually moving as he watched it.

But such changes of position as can thus be recognised are not only minute, insomuch that it is only after half a century of observation that even modern astronomy can detect them, but they afford no certain indication of real motion on the part of the star. *We* may be in motion—nay, more, it has been proved that we are in motion, that the sun with his whole *cortége* of planets and cometary systems is sweeping swiftly through space, and the apparent motion of a star may in reality be wholly due to the sun's motion. The very fact that by observing the apparent stellar motions astronomers have been able to guess the direction in which the sun is travelling through space shows that a large part at any rate of the stellar motions must be due to the sun's motion. And inasmuch as we are by no means certain of the direction in which the sun is moving, or of the velocity with which he rushes through space, we are not in any case able to determine how much or how little of a star's apparent motion is due to the solar proper motion. Furthermore, our uncertainty as to the distances of all save one or two stars renders us yet more doubtful how to interpret the stellar movements.

Still we may take it as proved by the mere determination of

the stars' proper motions, that these orbs are not fixed in space. Because we are quite certain that no motion which could possibly be assigned to the sun by astronomers would account for all the stellar motions, whatever assumption we might form respecting the stellar distances. That this is so will be evident from the simple consideration that there are cases where two stars near each other (in appearance) are moving in exactly opposite directions. We cannot possibly account for such motions as these by any assumption involving fixity for both stars and motion in the case of our sun alone.

Furthermore, the motions of those double stars which form binary systems suffice to show that motion is an attribute appertaining to some stars; and if to some stars as well as to our sun (which is but a star), why not to all?

But now notice a point of great importance in connection with the question of movements of recess or approach.

The apparent proper motions of the stars give us the means of estimating their probable motions of recess or approach, and thence of estimating our chance of determining such recessions or approaches.

In the first place it will be admitted that we have no reason whatever for believing the stellar motions to be limited to any special direction. If we imagine our sun for a moment set at rest, and that we could then tell the exact direction in which every star is moving, we should doubtless find that the stars were moving in every direction with respect to the lines of sight drawn to them. Here a star would be moving almost square to the line of sight; here nearly along it and towards us; here nearly along it and from us; and elsewhere every possible variety of direction would appear without the slightest preference (when the whole celestial sphere was considered) for one direction rather than another.

Amongst the immense number of stars, then, whose proper motions have been determined, there must be many whose motion is very nearly square to the line of sight from the observer on earth. And we have no reason for supposing that the stars which are thus moving have less or greater motions, on the average, than their fellows which are moving in other directions. Hence the motions of the former set of stars afford us a measure of the motions which those stars possess which are moving directly from or towards us, and so appear at rest; and though we can thus learn little respecting the real rate at which those stars are moving, for we know little respecting the real rate at which the other stars are moving square to the line of sight, we have a very satisfactory measure of the general rate at which the *relative* distances of the stars are diminishing or increasing.

For let E be the earth, s_1 the position of a star at the beginning of a century, s_2 its position at the end of a century, the star being one of those which is moving at right angles to the line of sight. And let us suppose that the star is also one of those which is moving most rapidly in appearance, so that the angle $s_1 E s_2$ which measures the proper motion in a century is as large as possible. Then we cannot assume with any probability that any star in the heavens has a greater proportional motion of recess or of approach than the motion indicated by s_1s_3 or s_1s_4 (each equal to s_1s_2). That is, the ratio of Es_3 or Es_4 to Es indicates the greatest relative change of distance we may look for among the stars during the course of a century.

But we can calculate the value of this ratio at once, and *so see at once what chance there is that a change in a star's brilliancy caused by such a change of distance could be estimated by means of our photometers.*

There is no star in the heavens which has so large a proper motion as ten seconds of arc per annum. Therefore in taking the angle s_1Es_2 at 1,000 seconds or 16′ 40″, we are taking a very favourable view of our prospect of estimating change of distance by change of brilliancy. If s_1Es_2 be an angle of 16′ 40″, then s_1s_2 is equal to ·004848 where Es_1 is called 1. Put for convenience s_1s_3 or s_1s_4 as equal to ·005. Then the brilliancy of the star at the beginning of the century would bear to its brilliancy at the end (supposing there has been in the meantime no change in the actual amount of light emitted by the star) the ratio

$$\left(\frac{1{,}000}{995}\right)^2 \quad \text{or} \quad \left(\frac{1{,}000}{1{,}005}\right)^2$$

according as the star had approached or receded from the earth with the assumed (and altogether over-estimated) velocity referred to. These ratios reduce severally to

$$\frac{101}{100} \quad \text{and} \quad \frac{99}{100}$$

In other words, the star's brilliancy would only be increased or diminished by about one hundredth part in one hundred years even in this altogether exceptional case.

No instrument ever yet devised by man could give any indications of so slight a change of brilliancy as this, even if it occurred in a single instant, so that one and the same observer could measure the star's light under unchanged atmospherical conditions.

We see, then, that the problem of attempting to measure the motions of recess or approach which the stars may have is one

which seems, on the face of it, as hopeless as that of determining what the stars are made of would have appeared twenty or thirty years ago.

Yet the problem has been mastered, and in a much more thorough manner than the seemingly simple problem of estimating the motion of the stars *athwart* the line of sight. In fact, whereas we know nothing (except in one or two cases) respecting the *amount* of this latter motion, for its angular measure affords no satisfactory criterion of the real motion in miles per year, we have a means of measuring the *real* velocity with which the stars are approaching towards us or receding from us. I proceed to show how this is done:—

We know that light is not a material emanation from luminous bodies, but consists in reality of the propagation of minute vibrations, taking place either in an ætherial medium pervading all space, or (as some physicists suppose) in the ultimate particles of what we ordinarily term matter.* Now it is to this property of light that the powerful mode of research which I am about to describe owes its effectiveness; and therefore it is necessary that we should attend somewhat closely to the peculiarities of wave-motion. Space will not permit me to enter at such length as I could wish into the considerations thus arising; and therefore I will confine my attention to a few primary points. The whole subject was dealt with in a highly interesting manner, I may remark, in the lecture delivered by Professor Miller to the working-men of Exeter [see p. 335], the careful study of which will well repay the student.

* It is often difficult in treating of the supposed ætherial medium to express oneself at once intelligibly and accurately. If there is an ætherial medium different in some essential properties from any of the substances we recognise as matter, yet that æther is still matter, and the laws which rule its movements are identical with those which govern the movements of other matter. By the term "laws" I here signify, of course, only the general laws of motion—not special laws, as gravitation or the like. I am particular in dwelling on this point, because it appears to me to be too often forgotten. Physicists speak, for instance, sometimes of the possibility that light-waves may be propagated to an *infinite* distance from the source of light. This is simply an impossibility. That light travels, so far as it does, without *appreciable* extinction, proves that the range of motion of the vibrating particles of the æther is very small indeed, compared with the wave-lengths; but this range, however small, must have a definite value at any given distance from the source, and the total amount of motion in *any* spherical surface round the source of light would have a definite and constant value. But to suppose a definite amount of oscillation in an infinite number of such spheres is to suppose that an infinite effect can accrue from a finite cause.

The simplest illustration we have of wave-motion is in the material waves which traverse the surface of water. Now here, be it noticed, we must not think of such waves as roll in upon the shores of the sea, but of the true waves which traverse the surface of open seas. In such waves there is not as there appears to be a rapid transmission of matter, but a simple oscillation of the particles of the water. Suppose there are long rollers sweeping over the face of the ocean. Then we should call the distance from the crest of one roller to the crest of another the *wave-length*; the difference of altitude between the crests of the rollers and the bottom of the "trough" between them would be the *wave-height*, or *wave-amplitude* as it is sometimes termed; and the rate at which the rollers travel would be the *velocity of transmission.* I mention these points, so that in dealing with other waves which we are unable to recognise as visible entities, the significance of the terms we shall have to make use of may be understood by a reference to the familiar relations of the ocean-rollers.

Now, suppose we wish to determine the wave-length of a rolling sea, what are the methods which would suggest themselves? If we could measure a line extending from crest to crest at any moment, we should, of course, know the wave-length; but failing (as might well happen) such a means as this, it is obvious that our resource must be to determine first the velocity of the waves, and secondly the number which pass in a given time. Suppose the first point gained (say by noticing the time which a particular roller occupies in travelling between two ships a mile apart), and, for convenience of illustration, let us imagine that the ascertained velocity of the rollers is 500 yards per minute. Now, suppose that an observer, counting the waves which pass the side of his ship, notices that 10 pass each minute. Then he knows at once that in that time the first which passed has travelled to a distance of 500 yards; and as all the 10 are distributed over that distance, each must be 50 yards in length, *if the ship has not moved in the interval.* But if the ship has moved, there is a difference. For supposing the ship to have moved in the same direction as the waves, and at the rate of 100 yards per minute, then the crest of the first wave is only 400 yards off instead of 500, and the wave-length is but 40 yards. In other words, the true length is less by 10 yards than the length which would be arrived at on the supposition that the ship is at rest. On the contrary, if the ship is moving at the same rate against the waves, the true distance of the first wave-crest is 600 yards, the true wave-length, 60 yards; and the effect of the ship's motion is to cause an apparent increase of 10 yards in the wave-lengths.

And clearly, if we could only conceive such a state of things as that the ship should be really at rest and the whole mass of the rolling sea bodily transferred under the ship, we should get a similar result. If the transference were in the direction of the wave-motion (which would correspond to a motion of the ship against the direction of the waves), the result would be an under-estimate of the wave-lengths; while in the reverse case the wave-lengths would be over-estimated.

Now let us consider the case of sound-waves. These are somewhat less familiar to us (so far as our ordinary modes of perception are concerned); but, inasmuch as we can more readily make experiments on them than on light-waves (owing to the enormous velocity with which the latter travel), they will serve to give a convenient illustration of the property we are to deal with.

Let fig. 2 represent a series of sound-waves generated by the vibrations of the tuning-fork A. When the right-hand prong is at *a* (the limit of a vibration), *a* is a place of aërial condensation; the next such place is at *b* (*ab* being the *wave-length* corresponding to the vibrations of the tuning-fork), the next at *c*, the next at *d*, and so on. The *wave-amplitude* does not concern us, but I may mention in passing that it is measured by the amount of the aërial condensation at *a*, *b*, *c*, *d*, &c. The tone of the sound depends on the wave-length *ab*, and a given tuning-fork will cause aërial waves of a particular length (that is, will give out its proper tone), *if it be at rest.*

But now suppose that the tuning-fork is being moved, and that with a velocity bearing an appreciable relation to the velocity with which sound travels. It will readily be seen that the tone now produced by the tuning-fork will be different from what may be termed its natural tone.

Thus suppose that during the interval which sound would occupy in travelling from *a* to *b*, the tuning-fork has been moved so that the prong *a* is at *a′*. During the interval the prong has made one complete vibration, and *a′* is now therefore a region of condensation instead of *a*; *b* is, of course, a region of condensation, just as it would have been if the fork had been at rest. Hence the wave-length has been reduced to *a′b*; and as all the waves proceeding from the neighbourhood of the vibrating fork are similarly affected, there results a series of waves, *ef*, *fg*, *gh*, &c., as in fig. 3.

On the other hand, if the fork had been moved in the opposite direction, there would have resulted the series of waves *kl*, *lm*, *mn*, &c., represented in fig. 4.

In the former case the tone of the resulting sound would have been more acute, in the latter it would have been more

Fig. 1

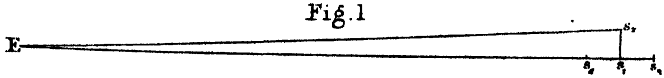


Fig. 2.

Fig. 3

Fig. 4.

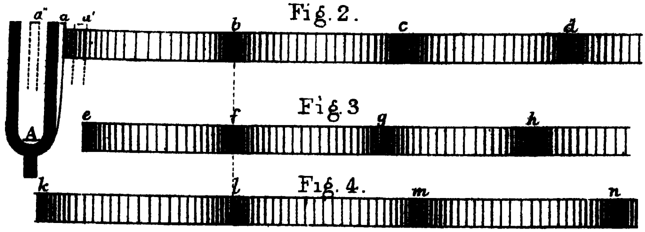
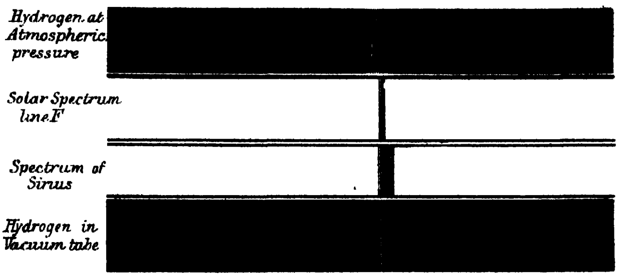


Fig 5.



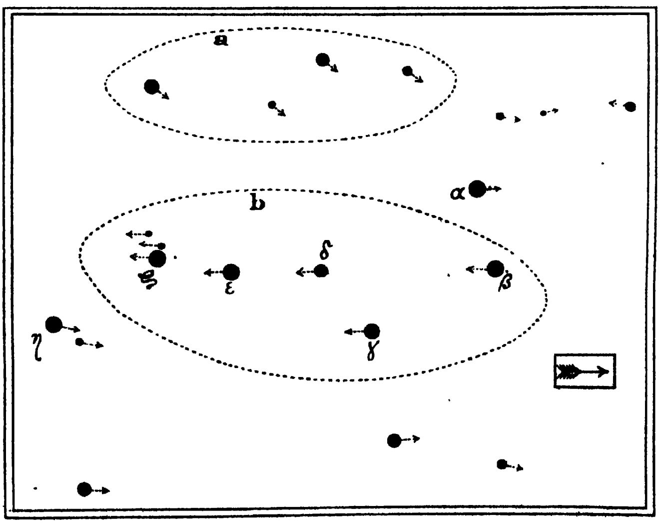


Fig. 6. Observed Proper Motions of stars in Ursa Major & neighbourhood.

The feathered arrow indicates the direction and amount of motion which the sun's estimated proper motion should give to stars in the above neighbourhood at the estimated mean distance of the 2nd magnitude stars.

grave, than the natural tone of the fork.* And a little consideration will show, that if, instead of the fork being moved, the ear were brought rapidly towards or from the vibrating fork, similar effects would follow—a rapid approach rendering the sound more acute, a rapid retreat rendering the sound more grave.

It is absolutely necessary, here, that the velocity either of the fork or of the ear should bear an appreciable proportion to the velocity of sound. In other words, aa' or aa'' must bear an appreciable ratio to ab. This is obvious, since what is wanted is, that ef or kl should differ appreciably from ab.

Now, if we only suppose the vibrating end a of the fork to be a particle whose vibrations are generating light of a particular wave-length—that is, of a particular *colour*, we see that the reasoning we have applied to sound-waves must be equally true of these light-waves. If the source of light be approaching us, through its own motion, or ours, or both, the waves will seemingly be shortened; and if the source of light be receding, the waves will be lengthened. In other words, there will be in either case a change of *colour*—the change being towards the blue end of the chromatic scale in the former case, and towards the red end in the latter.

But here, as in the case of sound, the condition has to be fulfilled, that the velocity of approach or recess shall bear an appreciable proportion to the velocity with which the waves travel; that is, to the velocity of light. Now, light travels at the rate of about 185,000 miles per second; and it seems hardly conceivable that any material movements in the universe should bear an appreciable relation to so enormous a velocity as this.

We could not hope, then, that any luminous object in the universe should indicate by a change of colour a change in the direction of its motion.

But this is not the only nor the principal difficulty in the application of such a mode of estimating motion. Döppler, who was, I believe, the first to suggest that the colours of the stars may serve to indicate whether these bodies are approaching us or receding from us, omitted to notice a circumstance which rendered his whole argument nugatory:—

In the case illustrated by figs. 2, 3, and 4, we dealt with the affections of only a single wave-length. If all stars sent us light-rays having a definite wave-length, then what we have

* Professor Tyndall has remarked that when a train rushes rapidly past a station a change in the tone of the whistle may be noticed by a person on the platform, the sound being more acute as the train approaches than after it has passed the station.

described would happen; and if our perception of colour were but sufficiently delicate, we could tell whether a star were moving from or towards us by the colour of its light. But this supposition implies that a star's colour should be monochromatic; and we know that the light from the stars consists of a combination of all the prismatic colours. But again, if the spectrum had definite extremities, and if no action *of any sort* took place beyond those extremities, then something like what Döppler conceived would take place. For then the light-waves of all lengths would be affected by a star's motion; so that if a står were approaching us, all the waves would be shortened, and a part of the red end of the spectrum would suffer extinction, while in the reverse case the blue end of the spectrum would be shortened. We know, however, that beyond the visible ends of the spectrum, waves too long and too short to affect the eye as light-waves are really in existence. Thus instead of the red end or the blue end suffering, in the cases imagined above, all that would happen would be that the heat-waves beyond the red end or the chemical rays beyond the blue end would become light-waves, replacing the red or blue end of the spectrum, as the case might be.

But these considerations, while showing that nothing can be hoped for from Döppler's suggested consideration of star-colours, show that a much more delicate and satisfactory test can be applied. We see that the whole spectrum is shifted bodily. *Therefore all its lines, whether dark or bright, must be shifted with it.* This is a motion we *may* hope to estimate, because we can bring into comparison with any line in the shifted spectrum the corresponding line belonging to some terrestrial element. We have, in fact, a test of the most extreme delicacy; and were it not that the most rapid stellar motions can produce but the minutest change in the position of the star's spectrum, we might *read off* the stellar motions of recess or approach as readily as we can determine the general character of the star's light by the same mode of analysis.

But when it is remembered that the velocity of light is about 185,000 miles per second, we see that a star must be moving with enormous velocity that its spectrum may exhibit any appreciable change of position. Our sun is supposed to be travelling at the rate of about 5 miles per second, and we have reason to believe, from some researches of Mr. Stone's, that the average motions of the stars may be about one-third greater,—say about 7 miles per second. Now, it has been estimated by Mr. J. Clark Maxwell that a velocity equal to that of the earth in her orbit, that is, rather more than 18 miles per second, would shift the sodium line D_1 through a space equal to about the tenth part of that which separates D_1 from D_2, these lines

forming what is commonly called the double line D of sodium. An idea, therefore, may be formed of the difficulty of estimating the stellar motions of recess or approach, unless in those exceptional cases where the star's real motion is much greater than the above-mentioned average.

Of course, the whole question is one of the dispersive power of the spectroscope; and inasmuch as a telescope of large aperture will permit us to use a higher dispersive power than we could apply to a smaller instrument, the size of our telescopes enters into this as into so many other questions of astronomical interest.

To secure the greatest dispersive power possible, without inconvenience, Mr. Huggins used the form of spectroscope exhibited in fig. 7, Plate XLIII. of my paper on the spectroscope, in the "POPULAR SCIENCE REVIEW" for April last. The reader is referred to that paper for a description of the qualities of this arrangement.

The star selected for the first application of the new method of research was Sirius, on account of its great brilliancy. It was necessary to consider some one recognised line of his spectrum, and the line corresponding to the solar line F (the blue-green hydrogen-line) was the one selected.

Fig. 5 shows the result of the experiment. The two upper spectra are not directly concerned in the method applied; but it is well to notice the perfect coincidence in position between the sharp dark line in the solar spectrum and the middle of the diffused line obtained from hydrogen at ordinary atmospheric pressure. Any want of coincidence *here* would have thrown doubt on the result of the experiment.

The hydrogen-line, actually compared with the dark and somewhat diffused F-line of the spectrum of Sirius, was obtained from hydrogen in the so-called vacuum-tube. Mr. Huggins made it fall side by side with the diffused dark line F in the spectrum of Sirius, and in some experiments he brought the bright line *upon* the Sirius-line. It will be seen from fig. 5 that the bright line fell sensibly away from the middle of the dark line. It became obvious from this that Sirius has a motion in the direction of the line of sight, and since the dark line was shifted towards the red end of the spectrum, it followed that the motion was one of recession.

From a careful measurement of the discordance between the two lower spectra of fig. 5, Mr. Huggins calculated that at the epoch of the observation Sirius was moving from the earth at the rate of 41·4 miles per second. But a part of this motion was due to the earth's motion in her orbit, and having made due reduction on account of this consideration, Mr. Huggins found that there remained a motion of recession *from*

the sun of 29·4 miles per second. Lastly, he considered the effect to be ascribed to the sun's motion, which is directed towards a point almost exactly opposite Sirius. If Otto Struve's estimate of the solar velocity is correct, then the motion of Sirius *in the galaxy* is reduced to somewhat less than 25 miles per second!

Interesting as this result is, the fact that the power of the new mode of research has been established is yet more so; for there is nothing to prevent the method from being applied in turn to all the lucid stars; nay even, with suitable instrumental power, to the telescopic orbs. The results obtained from such researches cannot fail to be of the utmost value.

I take myself a special interest in the new method of research, because I hope to find its results confirmatory and elucidatory of certain peculiarities in the stellar motions which I have recently been led to notice. On mapping the proper motions of about 1500 stars in the manner indicated in fig. 6, I have found in many parts of the heavens distinct traces of star-drift; that is, of the systematic motion of groups and sets of stars in particular directions. A singular instance of this is found among the bright stars of Ursa Major, five of which are moving (as shown within the oval, *b*, in fig. 6) in the same direction, and with the same velocity. Two other stars near ζ are also moving in the same manner. One cannot doubt that these stars are associated in some way, and so form a system; especially when it is noticed that the stars are moving in a direction almost directly opposed to that due to the sun's motion in space. Scarcely less remarkable is the community of motion observed within the oval *a*. And it will be noticed that among the remaining stars of the map there is a community of motion either *inter se*, or with the stars included within the ovals.

It will be a matter of extreme interest to determine by Mr. Huggins's method whether the stars which thus seem to form drifting systems have a community of motion of recess or of approach. Should this be the case, no doubt could possibly remain that the stars form sets or groups, and that there is no approach to that generally equable distribution described in our popular treatises of astronomy.

KENT'S HOLE.

BY W. BOYD DAWKINS, M.A., F.R.S.

THE systematic exploration of Kent's Hole, under the auspices of the British Association, has been carried on since the year 1865, and is likely to prove a *pièce de résistance* for a very long time to come. Up to the present time it has yielded upwards of fifty thousand bones, and a large number of other objects of interest; it has also afforded evidence of extremely high value as to the enormous antiquity of the human race. It has, however, fared badly in the sporadic fashion in which it has been laid before the public, the only authentic accounts being the reports of progress furnished by the Kent's Hole Committee, from which it is almost impossible to gather an adequate idea of the cave and its wonderful contents. It would indeed almost seem as if the exploration were attended by a fatality that forbids the public from acquiring any exact knowledge until a great deal of the interest is lost, for the admirable investigations of Mr. McEnery, begun in 1824, were not published until 1859, and even then in a very disconnected fashion. To supply this need as far as may be, by adding the information in the Reports to that contained in the notes above alluded to, and thus to construct a connected story, is the object of the following outlines.

Kent's Hole has been known from time immemorial, but until the year 1824 it was not rifled of any of its treasures, when it was visited by Mr. Northmore for the purpose of ascertaining "whether it were or were not a Mithratic cavern; for the Druidical priesthood, like their Egyptian, Chaldean, and Brahminical brethren, worshipped, in such cavernous recesses, whether artificial or natural, the Solar God."* He expressly states also that he wished to discover organic remains, for the excitement consequent on Dr. Buckland's discoveries in Kirkdale and other

* "Cavern Researches," by the Rev. J. McEnery. Edited by E. Vivian, 1859.

caves was then at its height, and the Reliquiæ Diluvianæ was known better in this country than the great work of the immortal Cuvier. Fortunately his enthusiasm was rewarded by the attainment of both objects; for, besides the discovery of "the baptismal lake of *pellucid water*, the *creeping path* of stone, the mystic gate of obstacle, the *oven mouth*," which satisfied him that the cave had been the Temple of Belus, he broke through the stalagmite covering of the floor, and found remains of the hyæna, fox, and other animals; to him, therefore, Mr. Pengelly rightly assigns the credit of the first discovery of the fossil mammalia. From this time there was no printed record of the explorations, that were conducted by many people, that is of any importance, until the year 1840, when Mr. Godwin Austen published his opinion that hyænas had dwelt in the cave, and that flint implements "occur in Kent's Cave under precisely the same conditions as the bones of all the other animals." The value, he goes on to say, "of such a statement must rest on the care with which a collector may have explored; I must therefore state that my own researches were constantly conducted in parts of the cave which had never been disturbed, and in every instance the bones were procured from beneath a thick covering of stalagmite; so far, then, the bones and works of man must have been introduced into the cave before the flooring of the stalagmite had been formed."* In 1847, and again in 1856, Mr. Vivian corroborated the truth of Mr. Austen's observations. Three years afterwards he published Mr. McEnery's manuscript, written in 1834, and which doubtless furnished the clue to all the investigators from the time it was written. Had Mr. McEnery's intention of publishing a memoir of Kent's Hole been carried out immediately after its exploration, we should certainly not have been obliged to wait until the year 1857 for the discoveries of M. Boucher de Perthes in the valley of the Somme to prove the high antiquity of man, and archæology as a science would have ranked as high as palæontology. Such is the brief epitome of the literature of the cave. Mr. McEnery's famous collection was, at his death, scattered almost literally to the four winds, but the lion's share found its way to the British Museum, where, together with his unpublished plates, drawn by the most eminent artist of that day, Mr. Scharf, they form the basis of Professor Owen's list of animals published in 1846.†

We will now pass on to the consideration of the contents of the cave, beginning with the most modern, and thus reversing the usual geological order. The cave itself consists of two

* "Literature of Kent's Cavern, Torquay," by W. Pengelly, F.R.S. Devonshire Association, 1868.

† "British Fossil Mammals," 8vo. 1846.

parallel series of chambers and galleries, an eastern and a western, which penetrate the Devonian limestone in the line of the joints. It has a northern and a southern entrance, which occupy very nearly the same level on the low cliff on the eastern side of the hill; the latter are "about fifty feet apart, from a hundred and eighty to a hundred and ninety feet above the level of mean tide, and about seventy feet above the bottom of the valley immediately adjacent."* The largest chamber of the eastern series is sixty-two feet from east to west, and fifty-three from north to south. The contents of the cave may be divided into three great divisions: the pre-historic, which is represented by a layer above the stalagmite, but which in some places is covered with a thin stalagmitic crust; that which lies underneath the solid and continuous stalagmite; and lastly, that which belongs to an epoch when an older stalagmitic crust was formed, which has been for the most part destroyed, but which is still represented by enormous detached blocks. In the first of these Mr. McEnery found fragments of pottery, calcined bones, charcoal and ashes, and arrow-heads of flint and chert. The pottery is of the rudest description, made of coarse gritty earth, not turned on a lathe, ornamented by zigzag indentations similar to those found on the urns in the barrows of Wiltshire and in the cave of Kuhlock; along with them were round slabs of roofing slate of a plate-like form, some crushed, others entire, which probably served for the covers of the cinerary urns, indicated by the fragments of pottery. Near the entrance he found "articles of bone of three sorts, some of an inch long and pointed at one end, or arrowheads; others about three inches long, rounded, slender, and likewise pointed." They may have been either bodkins, or pins for fastening the garments of a savage race.

> The shaggy wolfish skin he wore
> Pinned by a polished bone before.

"The third article does not seem quite so easy to explain; it is of a different shape, quite flat, broad at one end, pointed at the other;" the former retaining the truncated form of a comb which has lost its teeth. "Nearer the mouth were collected a good number of shells of the mussel, limpet, and oyster, with a palate of the scarus" (now in the Oxford Museum). In the same passage there was a stone hatchet or celt of syenite. "As we advanced towards the second mouth on the same level were found, though sparingly, pieces of pottery and round pieces of blue slate, about an inch and a half in diameter, and about a quarter thick." There were also "several round pieces of sandstone grit, about the form and size of a dollar, but thicker

* "Report of the British Association," 1867, p. 24.

and rounded at the edge, and in the centre pierced with a hole, by means of which they seem to have been strung together like beads. Clusters of small pipes or icicles of spar, such as depended from the roof at our first visit, we saw collected here in heaps buried in the mud. Similar collections we had occasion to observe, accompanied by charcoal, throughout the entire range of the cavern, sometimes in pits excavated in the stalagmite. Copper ore "was picked up in the same deposit—a lump much oxydised, which the late Mr. Phillips analysed, was found to be virgin ore."*

By the term virgin ore it is very possible that native copper may be implied, which occurs not only in Cornwall, but also in Ireland and Scotland. It is worthy of remark that native copper has been worked by the Indians on the shores of Lake Superior from time immemorial, and that a few copper implements have been found both in Ireland and Scandinavia.

There was also evidence of the cave having been penetrated by iron-using folk; "in an interesting little grotto formed by the bending over a flag of stalagmite into an arch elevated only two or three feet above the level of the floor. Its mouth was closed with blackish mould, in digging which in quest of pottery we broke into a circular cell" of small dimensions, with its "floor covered by stalagmite, in the surface of which were inserted large shells with the cup uppermost, as if placed to collect the droppings. The entire skeleton of an animal resembling a badger, and portions of the upper jaw of a hog, with one of its tusks indicating great magnitude, were scattered over the earth, and in the midst of all a barbed spear of iron. These relics were severally invested with a crust of stalagmite like the specimens from the German and English dropping-wells, and reposed with their under surface inlaid in the floor. Many of the bones, when stripped of their spar, were found discoloured, as if by smoke; pieces of charcoal indicated the remains of a fire." Mr. McEnery did not find any implements of bronze, but his omission has been supplied by the explorations of the Kent's Hole Committee in 1865, in which a bronze "fibula, the bowl and part of the stem of a spoon, a spear head, a fragment of a socketed celt, two or three rings, one coil of a helical spring, a pin" nearly four inches long, and an object "resembling a horseshoe in form, but not more than an inch long," were also found. There is therefore evidence that the black superficial layer belongs, not merely to the neolithic, but also to the bronze and the iron ages, and from the occurrence of Roman pottery it may in part be referred to a time not more remote than the Roman occupation. This association of objects belonging to widely

* McEnery, "Cave Researches," pp. 14, 15, 16.

different periods is just what we might expect when we consider that caves have been used for places of habitation from the remotest times to the present day.

But Kent's Hole had also been used as a place of sepulture, for Mr. McEnery discovered a skeleton lying at full length in it, as well as fragments of burnt human bones, which probably indicated the habit of cremation. In one spot the traces of occupation overlay a burial-place. Fragments of pottery, both plain and ornamented, writes Mr. McEnery, lay strewed about in abundance, in a black layer, containing quantities of marine and land shells, such as patella, limpet, ostrea, turbo, pinna, helix, solen, &c., as well as bones of stag, fox, rabbit, and small rodents. Among the animal remains were some curiously fashioned by art, being sharpened at one end for piercing. "A large rock now lay between us and the next stratum. On lifting it over a still more startling discovery was displayed:—pottery, charcoal, human teeth and bones, flint relics, copper ornaments and mountings of tin; two lumps of virgin copper ore were pressed together into a cake, on a large flat stone, against which they had been violently crushed by the superposition of the rock which we had just removed. We collected on this spot the remains of two sepulchral vessels; one was a plain urn slightly indented, coarse and sunbaked, with its walls about half-an-inch thick; it most probably contained the ashes which were spilt about, and which enveloped two black spear heads. The other fragments were thinner and highly ornamented, answering in every respect to those small figured vases found in the barrows, and designated by Sir Richard Hoar drinking-cups. The pieces of both vessels were scattered at a short distance from each other on the flag, and were evidently connected with the human bones, flint relics, and other substances just described as grouped together; the whole forming a distinct interment." So far as I know this is the only case on record of the occurrence of tin in an interment of this kind. It is a most unfortunate thing that the prehistoric remains found by this indefatigable explorer, have been so scattered that it is almost impossible to trace them, or to find with absolute certainty any exact specimen which he describes. In the Oxford Museum there are bones from this black layer, which prove that the prehistoric folk who lived in the cave, or who used it for purposes of sepulture, fed upon the small celtic short-horned ox, the *Bos longifrons*, an animal which cannot boast of higher antiquity than the modern alluvia and peat bogs, and which was most probably introduced into Europe during the neolithic age. In the Swiss phalbauten of the later period, it is found along with the horse, dog, and goat. It probably accompanied a nomad race from some area to the east and south from Central Asia.

It occurs universally throughout France, Germany, Britain, and Italy, and may be taken as the characteristic animal of the prehistoric epoch. In Gaul and Britain it supplied the Roman legionaries with beef.

In addition to many objects similar in their nature to those which have been described, amber beads, spindle whorls, a fragment of polished flint celt, and a portion of a cake of smelted copper, have been discovered by the Kent's Hole Committee in the prehistoric layer.

We now pass on to a brief account of the underlying deposit, which furnished to Mr. McEnery and to all subsequent explorers so rich a harvest. Immediately under the black superficial bed is a layer of stalagmite of varying thickness, which forms an adamantine pavement over the earth, large blocks of stone, and the remains of the postglacial animals. In one part, above a spot whence Mr. McEnery obtained flint implements, it was 2 ft. thick; in another it was no less than 12 ft. The red earth is that which is usually found in caverns, and has been carried in by the percolation of water through the rock. The large angular blocks which it contains consist of Devonian limestone detached from the roof, and of an ancient crystalline stalagmite, to which we shall revert towards the conclusion of this essay. The small rounded pebbles of granite and other foreign materials have been washed in by the flow of water from some bed of gravel in the neighbourhood. The remains of the animals are, more or less, gnawed and scored by teeth like those found in Wookey and Kirkdale. They prove that the cave was inhabited by hyænas, and that the animals to which they belonged fell a prey to those destructive carnivores. The remains in the cave belong to the following species:—

Rhinolophus ferrum equinum	Cervus elaphus
Sorex vulgaris	Bos primigenius
Ursus arctos	Bison priscus
Ursus spelæus	Sus scrofa
Ursus ferox	Equus caballus
Meles taxus	Rhinoceros tichorhinus
Mustela erminea	Elephas primigenius
Lutra vulgaris	Lepus cuniculus
Canis vulpes	Lepus timidus
Canis lupus	Lagomys spelæus
Hyæna spelæa	Arvicola pratensis
Felis leo	Arvicola agrestis
Machairodus latidens	Arvicola amphibidus
Cervus megaceros	Castor fiber
Cervus tarandus	Mus musculus

To this list must be added *Homo palæolithicus*, as he may

be called, for his implements of chert and flint have been found wherever the stalagmite has been broken through, in intimate association with the bones and teeth of the other animals. To pass over the implements found by Mr. McEnery, Mr. Godwin Austen, and others, those discovered by the Kent's Hole Committee, up to the year 1867, amount to over 700. "They are divisible into three classes—mere flakes, lanceolate implements pointed at one end and truncated at the other, and oval implements, convex on both sides and worked to an edge all round the margin." * The largest specimen of the first class is nearly five inches long; they all belong to the types found in such abundance by Messrs. Lartet and Christy, in the Reindeer caves of the Dordogne. Near the entrance, indeed, a black layer occurred, underneath the stalagmite, that was perfectly crammed with ashes and the relics of feasts, which furnished no less than 366 implements. A bone piercer also, and a harpoon, were found associated with the remains of rhinoceros, hyæna, and the other cave mammals. Three other bone implements have also been met with — a portion of a highly-finished harpoon, with barbs on either side of the axis, a bone pin, and a bone needle. In fine, the human implements in Kent's Hole, whether they be chert, flint, or bone, so strongly resemble those found in the Reindeer caves of the Dordogne, both in form and workmanship, that there can be little doubt of their having belonged to savage tribes of precisely the same habits, who lived on the chase, and eked out their miserable lives by fishing.

One of the most remarkable facts, brought to light by Mr. McEnery, is the former presence of the sabre-toothed tiger in the cave. Its characteristic canines were found associated with thousands of the teeth of the horse and the hyæna, "in a spot fat with the sinews and marrow of more wild beasts than would have peopled all the menageries in the world." Kent's Hole is the only place where this fell carnivore is found along with the remains of the mammoth, reindeer, and other characteristic postglacial mammals. It belongs to an archaic type which sprang into existence during the Miocene times in France, Germany, and Switzerland, that preyed upon the Hipparion and Antelope on the plains of Marathon and on the Indian flanks of the Himalayahs—to a type that coexisted with *Elephas meridionalis* and Mastodon, during the Pliocene times in France, Germany, Britain, and Italy, and in South America preyed on the gigantic Sloths and peculiar Horses of the Brazilian caves.

We have already mentioned the large masses of stalagmite which occur in the cave earth; they prove indisputably that there was a stalagmite floor in the cave before the introduction

* Report, 1866, p. 8.

of the earth, and long before the formation of the present stalagmite pavement. They are remarkable for their hard crystalline structure, and in one or two cases they have yielded fragments of very dense mineralised bone. In a portion of the cave, called the gallery, there is evidence of the undisturbed portion of the crust, in "a ceiling" or uppermost floor, that extended from wall to wall, "without further support than that furnished by its own inherent cohesion. Above it there is in the limestone rock a considerable alcove. This branch of the cavern, therefore, is divided into three stories or flats—that below the floor occupied with cave earth, that between the floor and ceiling entirely unoccupied, and that above the ceiling also without deposit of any kind." * From its being stained with cave earth, as well as from its position, the ceiling at the time of its deposition must have been supported by a layer of cave earth, and therefore the inference becomes necessary that, while it was being formed, the cave must have been filled up to its level. It would, indeed, be as impossible for a solid calcareous sheet to be formed in mid air as it would be for a sheet of ice to be formed without resting on the water. From some cause or other this ancient stalagmite has been in part broken up, and the materials by which it has been supported have disappeared. That, however, even prior to its formation, animals dwelt in the cave, is proved by the bones which are imbedded in the large fallen masses. Moreover, there is reason to believe that certain fragments of bone and splinters of teeth, remarkable for their mineralisation, that have been found in the earth now occupying the cavern, were derived from this more ancient deposit; for they differ essentially from the remains with which they are now associated, being heavier and of a more crystalline structure. Some splinters have assumed the fracture of green-sand chert. So hard, indeed, was one of the canines of bear, that it has been splintered by the hand of man into the form of a flint-flake, and has evidently been used for a cutting purpose. Its fracture proves that it was mineralised before it was splintered; and as it was found in the present cave earth, it must have been fashioned while the cave was being inhabited by palæolithic man, prior to the accumulation of the earth. For these reasons the evidence in favour of these denser remains having belonged to the deposit which once supported the ancient floor seems to me incontrovertible. This view opens up an entirely new field for investigation as to the discovery of the sabre-toothed tiger, for it is very possible that this pliocene mammal may really belong to the older cave earth, and not to the more modern, in which the remains of the postglacial mammoth, woolly rhino-

* "British Association Reports," 1866, pp. 45.

ceros, and the like, occur. But whether it be true or not, it adds a tenfold interest to the exploration of the cave, because there may be still left, in some nook or corner, masses of the older breccia, containing forms of life that had passed away before the post-glacial invaders from the north had arrived in western Europe.

From this brief sketch it will be seen that the contents of Kent's Hole are divisible into three distinct groups, each of which is separated from the others by a blank of indefinite length, not to be summed up in years. At the top there is the prehistoric series, below that the postglacial cave earth series; and, lastly, imbedded in the latter, are ossiferous masses of stalagmite which belong to a much more ancient order of things, and which chanced to have been left by those causes by which the ancient cave earth was removed. Whatever those causes were—and they must have been aqueous—they did not affect Kent's Hole alone, but also the neighbouring cavern of Brixham, and in precisely the same way.

THE LINGERING ADMIRERS OF PHRENOLOGY.

By Professor CLELAND.

[PLATE LII.]

TO slay those that are already slain may be excellent sport to employ the courage of a Falstaff, but the reader perusing the title of this article may perhaps be disposed to ask why the pages of this review should be occupied with the discussion of so dead a doctrine as Phrenology. The answer is, that although phrenology never had much countenance from scientific men, and has long since been banished by them, with one consent, to the limbo of exploded chimeras, yet among educated men and women not physiologists, and not pretending to know anything about anatomy, it still holds its ground wonderfully, and counts considerable numbers of people who believe in its miraculous skull maps; while, beside these, there is a far more numerous class of persons, including, undeniably, a certain proportion of scientific men, who, admitting that the minute division of the cranial vault into organs is untenable, yet profess belief in a larger mapping, and have no hesitation in relegating the reasoning faculties exclusively to the forehead, and the moral sentiments and volitionary powers to other parts of the brain-pan.

This state of matter does not exist without a sufficient reason to account for it. Long before the time of Gall and Spurzheim, men were in the habit, sometimes consciously, and much more frequently half unconsciously, of gauging the intelligence and moral qualities of their neighbours by their personal appearance generally, and more particularly of estimating them according to crude impressions derived from the shapes of their heads. They judged rightly enough that there was some connection between brain and mind. Much of the evidence that the brain is the organ of the mind is so palpable that it could not remain long hid. The effects of injuries and diseases of the brain in disturbing the intelligence, its larger size in the higher than in the lower classes of animals, and more especially its distinctively great development in man: these circumstances, together with the indubitable frequency of finely proportioned heads among

persons of distinguished talent, and the tendency of the eye to dwell on clumsy or forbidding proportions, when occurring in persons brought under notice as stupid or depraved, all seemed, though vaguely, to point out that a scrutiny of the amount of the brain and shape of the cranium was likely to afford an index of the strength and qualities of the mind. Gall propounded his theory that different portions of the brain were the organs of different mental faculties, and that according to the size of those different parts of the brain, so the mental qualities varied; and making continual observations on the heads and characters of those with whom he came in contact, he covered the surface of the cranial vault with a map, which at once professed to indicate the correct analysis of the mental faculties, and to assign to each of these its proper habitation. The psychological difficulties of their pursuit do not seem to have weighed heavily on either Gall or his followers; and as for the exceedingly great obstacles in the way of estimating the proportions of even large masses of the brain by observation of the surface of the skull, not only did the phrenologists strangely ignore them, but we are constrained to say that even anatomists have been very slow to appreciate them. Phrenology, however, supplied a want which the public felt, seeming to furnish an answer to questions which were continually obtruded before them, and giving precision to the notions founded on fact which had previously possessed their minds: this, we believe, is the principal reason why phrenology became so popular as it did, and why it is not yet eradicated from the public mind.

Probably scientific men, in dealing with phrenology, have been too much in the habit of contenting themselves with merely pointing out that the system is certainly a blunder; and their hearers have gone away impressed with the conviction that it is impossible for the uninitiated to argue with experts, yet saying in their hearts that they are sure there is a mistake somewhere, and unwilling to part with all their beautiful theories and get nothing in exchange. Iconoclasm is not popular: when an image is thrown down it is well that its destruction should make way for a flood of light sufficient to satisfy the eye in its stead. This is an achievement not easy to accomplish, but, actuated with the laudable motive of attempting it, the writer will try, not only to reiterate the reasons why phrenology cannot possibly be true, but to give some idea of what is positively known regarding the brain and its functions, and to point out in what direction speculation may be still legitimately indulged.

Let us begin at the beginning, and try and form some general notion of what the brain is as it is known to the anatomist, before we dogmatise about the functions of the parts which happen to come in contact with the upper and lateral walls of the skull.

If a chick be examined in a hen's egg which has been allowed to hatch for twelve hours, or if the embryo of any vertebrate animal be examined at a similarly early period, it will be seen to exhibit a long open furrow, the walls of which are the first portions of the animal to be formed. The most superficial layer of substance entering into the construction of this furrow may be described as a long ribbon, consisting of two symmetrical parts separated by a longitudinal groove: this is the embryo brain and spinal cord, constituting one continuous structure, the cerebro-spinal axis. The parts which support the ribbon form in like manner the cranium and the spinal canal, primarily undistinguishable one from the other. The edges of the furrow rise up and become united, so that the open furrow is converted into a closed cylinder; and similarly the ribbon within it has its lateral edges brought together, so that the brain and spinal cord, at an early period of their development, form one continuous tube. The walls of the tube so formed become ultimately much thickened and exhibit two kinds of texture, which, from their colour, are distinguished as the grey and the white. In the case of so much of the tube as lies in the spinal canal and is afterwards termed spinal cord, the development proceeds very regularly; white matter is deposited on the outer wall of the cylinder, and grey matter on the inner wall, until it appears solid. A minute canal, however, the central canal of the spinal cord, continues to traverse its whole extent throughout life, and is the remains of the original hollow of the tube. Towards the lower part of the cord in birds there is even a space called the sinus rhomboidalis, where the cylinder is never completed, and the central canal is open on the dorsal aspect. Now, however different the brain may be in the adult condition from the spinal cord, it is extremely interesting to note that it is the anterior portion of the same cylinder, but that the cylinder undergoes some bendings, its walls are greatly thickened in some places and imperfect in others, and the continuation of the central canal is in some places greatly dilated, and in others contracted.

As respects texture, there is much in common between the brain and spinal cord. They are similar in appearance, and both consist of true nerve tissues, with a fine reticulum of supporting substance in which those more important elements are imbedded. The proper nerve tissues are two in number, nerve fibres and nerve corpuscles: the nerve fibres are long threads which have the property of transmitting along their course a certain change of condition which constitutes nervous influence, and which, it may be mentioned, is a purely physical action, not electrical, but involving in its operation electrical changes. Nerve fibres transmit this influence, but have no power of originating, directing, or modifying it: they are simply con-

ductors, and such nerve fibres are the essential elements in all the nerves throughout the body. Nerve corpuscles are bodies of which it is only necessary to say that they present a variable number of poles or branches, and there is no reasonable doubt that those poles are in direct continuity with nerve fibres. According to circumstances little understood, these corpuscles have the property of modifying impressions of nervous influence, and of directing them into different channels with which their poles communicate. Now the white substance of the brain and spinal cord contains only nerve fibres without any nerve corpuscles, these latter being found exclusively in the grey substance. It is quite plain, therefore, and universally recognised, that the white substance is only useful as containing channels of communication between different parts of the grey, and also between grey substance and the muscles and sensitive parts throughout the body. But even grey substance is not always or even generally capable of being affected directly by the consciousness; and in the case of the spinal cord, it is very certain that consciousness resides in no part of it, either white or grey. The spinal cord is the centre with which are connected the nerves of the muscles and integuments of the greater part of the body, and in the ordinary actions of the body what usually happens is this, that impressions made by the contact of external objects on the terminations of sensory nerves in the integument are transmitted by them to the nerve corpuscles of the cord, and, through series of these, conducted to the parts of the brain which are in immediate connection with consciousness; while also, when the mind wills certain movements of the body, the stimulus proceeds from those parts of the brain, and, by some altogether unknown mechanism, is ultimately so distributed that there extend from the grey matter of the cord impressions along the nerves so adjusted as to produce precisely that amount of contraction of muscles, of whose existence the mind is utterly ignorant, which is necessary to effect the required result. But it is always the same kind of stimulus, the nervous influence, wherever it issues from, which acts upon the cord. Thus, for example, when the cord near its upper part is severed from the brain by an injury, there is loss of all sensation and voluntary motion in the parts supplied by it below the place of lesion, the consciousness being no longer in communication with those parts; but irritation of the integument still sends a current as before to the spinal cord, and this being distributed by the corpuscles of the grey matter, and descending again by the motor nerves, causes involuntary contraction of muscles. This is probably the simplest possible example of the phenomenon termed by physiologists reflex nervous action.

We have ventured on this extremely cursory and general

survey of the spinal cord, the simplest portion of the cerebro-spinal axis, in order that the general reader may form some conception of the kind of mechanism which extends through the more obscure and intricate portion, the brain. To explain fully the extremely complex structure of the brain would require much greater detail than is allowable in an article like this, but a general idea of the most important facts will best be arrived at by pursuing the account of its early development, which we have already begun.

The cylinder which we have traced in the embryo, so far as the spinal cord is concerned, is, immediately on its closure, expanded in its cranial part into a series of three primordial vesicles, and immediately afterwards two little hollow buds, called the hemisphere vesicles, project laterally from the foremost of the series. Without tracing the history of the primordial vesicles, it is sufficient for our present purpose to point out that the cerebellum is originally a part of the hindermost, projecting upwards as a hollow pouch, and that it is quite certain, from experiments on the lower animals, that no consciousness whatever resides in any of the parts developed from that vesicle; also it is equally certain that not more than the very feeblest consciousness resides in those parts into which the walls of the two other primordial vesicles are developed. These parts are devoted to the carrying on of obscure functions connected with the sensibility and movements of the body strictly comparable with the functions of the spinal cord, and entirely of a physical description: the organs of the mental faculties are the developed hemisphere vesicles, and these only. The hemisphere vesicles rapidly enlarge and extend backwards over and around the other parts of the brain, so as to reach to the cerebellum behind, come in contact with the whole roof and sides of the skull and a large part of its floor, and press one against the other in the middle line of the whole length of the skull for an average depth of a couple of inches; and early in embryonic life they are already much the most bulky parts of the brain.

The grey matter which lines the whole length of the cerebro-spinal cylinder fails to be developed in the hemisphere vesicles, except at one part placed at the neck of the vesicle, and called by anatomists the corpus striatum, but of which we know nothing in respect of function, and can only note that it is traversed by the whole mass of fibres joining the hemisphere vesicles with the cord and cerebellum. The whole of the rest of the hemisphere vesicle, or, as it is termed, the cerebral hemisphere, consists of an enormous mass of white matter, with a superadded layer of grey matter on the outside. The cerebellum has the same peculiarity of having its grey matter on the surface, and it is curious to note that both the grey matter on the cerebellum

and that on the cerebrum, while differing one from the other in minute structure, differ still more from the grey matter which is found elsewhere, and the function of which is, as we have seen, in a general way, well understood. Also the cerebellum and cerebral hemispheres resemble each other in being thrown into numerous elevations and depressions, in order to expose a larger extent to the vascular membrane on their surface, which sends its minute branches into them. These circumstances might plead a little for the doctrine that the cerebellum is connected with a psychical faculty, whatever that might be, but its totally different source of origin is clearly opposed to such a notion; and we are not left merely to speculate on the subject, for both disease in the human subject and experiment on animals teach us that when the cerebellum is destroyed, the power of combining movements so as to regulate and guide them is lost, the limbs being still capable of being moved, but walking and handling being impossible. Thus it is certain that the function of the cerebellum is totally different from what the phrenologists hold it to be.

Examining the cerebral hemispheres in different animals, and proceeding from the lower to the higher forms, a progress in development is found, similar to the progress made in embryonic life. Thus in fishes they are represented by very small parts in the fore part of the brain; in birds they have not extended sufficiently backwards to be in contact with the cerebellum, and their bulk is due almost entirely to the corpora striata; in rodent animals their surface is smooth; and, as one passes to the higher groups of mammals, more and more complicated convolutions of the surface are met with; while in man by far the greatest complexity is found.

Whatever the particular cerebral changes may be which accompany and are necessary for thought, there can be no question that they occur in the grey matter, and that the white matter is only useful by bringing the different parts of the grey matter into communication one with another, an end which it accomplishes very thoroughly by its complicated commissures and countless bundles of fibres taking all directions. Judging, then, from comparative anatomy, and even on phrenological principles, one would expect that, among men, the greater the amount of grey matter of a given quality, the more effective would the hemisphere be for the exercise of the mental faculties; and this, there is good reason to consider, is to some extent actually the case. But the quantity of grey matter varies according to other circumstances besides the size of the skull. The vertical depth at any one spot, from the surface of the grey matter down to the white, differs in different brains; and what is probably more important is, that the complication of the

convolutions varies greatly. Complex convolutions are probably more important than the thickness of the sheet of grey matter, because it is obvious that not only quantity but activity of texture will be an advantage; and complexity of convolutions involves increased surface of vascular membrane, sending its blood-vessels into the grey matter, and furnishing its elements with the means of activity. In harmony with this supposition, the simplest condition of the convolutions has been found in the brains of the lowest races of humanity, and Wagner's comparisons of the brains of various persons of ability with others from persons of supposed limited intelligence show more complicated convolutions in the former than the latter, although at the same time exhibiting apparent exceptions to that rule. It may be noticed in this connection, that if two skulls of the same cranial capacity be one long and narrow and the other short and broad, the long and narrow one is that which has the greatest amount of surface, and is therefore most favourable for a large proportion of grey matter; so that, *ceteris paribus*, the long skull has probably an advantage over the broad skull; while, on the other hand, there is no doubt that, with a given model of skull to start from, the tendency of expanding hemispheres is rather to increase the breadth than the length.

Turning now to the fundamental doctrine of phrenology, that different parts of the cerebral hemisphere are the organs of different mental faculties, we feel assured that no physiologist will hesitate in giving it a distinct and emphatic denial. It is true that the convolutions of the hemispheres are so constant that they are named; but the existence of the convolutions is not for the sake of dividing the hemispheres into parts, and does not do so, but only affords, as has been said, facility for vascular supply; and, at all events, the convolutions have not the smallest correspondence with the phrenological organs which cross them, cut them up, and combine them in the most regardless fashion.

But the fatal objection to the doctrine of different functions in different parts is to be found in the teachings of experiment and pathology. An animal will bear to have its cerebral hemispheres gradually sliced away; and the slicing may be done in any direction with the same result, namely, gradually increasing stupidity, but with no change of character according as one or other phrenological organ is removed.

So also, persons have often recovered from wounds from which portions of the brain have protruded and been amputated, but it makes no difference what part of the hemisphere is injured; nor, in cases of tumours destroying portions of the hemispheres, is it at all possible to state the position of the tumours from any alteration in the mental constitution of the

patient. The symptoms are perfectly irrespective of the part of the hemisphere affected.

Not only, however, are the hemispheres not divided into organs, but, supposing that such organs existed, it would be impossible to tell their size by the phrenological method. The bulging of any portion of the cranial vault does not indicate an increased thickness of the grey matter at that part, or give any clue to the degree of development of the convolutions opposite to the spot. Indeed, the shapes of skulls indicate differences of form in the central white matter of the hemispheres, rather than local differences of development of the grey matter on the surface. The sheet of grey matter is disposed with tolerably even thickness over great tracts, and always reaches its greatest complication of structure in the same region—namely, towards the back part.

It is not necessary to dwell at length on what has been discussed *ad nauseam* long years ago,—how one-half of the surface of the hemisphere, namely, the part looking to the middle line and to the base, is beyond the reach of all phrenological observation; and how the most minute organs have been crowded by phrenologists over a part of the skull whose configuration is certainly not in the slightest degree affected by the form of the brain, namely, the line of bone immediately over the nose and eyes. But the accompanying figure speaks for itself. It has been obtained by tracing from a horizontal section of a skull, made half an inch above the orbit, dividing the phrenological organs of individuality, size, weight, colour, and order, as indicated by Spurzheim, and passing quite above three still more nonsensical organs, viz. that of form, lying on the nasal cavity, calculation, which is never anything but the solid external orbital process of bone, and language, the so-called large size of which is an appearance of the eye dependent on want of projection forwards of the face bone on which it rests.

Turning now to the less special but more generally diffused notions respecting localisation of different faculties in different parts of the skull, a few words may be said about fine foreheads. It may be freely granted that a handsome forehead is a beautiful feature, and one frequently, though by no means always or exclusively, met with in persons of talent; but a spacious and well-shaped forehead by no means necessarily indicates preponderance of the frontal lobes of the hemispheres over the others. This, with some other interesting points, will best appear by considering the general shape and mode of growth of the cranium. The cranial cavity, as has been already said, is originally the upper part of a long cylinder, the remainder of which becomes the spinal canal; and it may be regarded, even

in its adult state, as a cylinder much modified and distorted. At an early embryonic period it is in all animals curved remarkably downwards on itself. Examining it, however, in adults, the total curvation of the cranial cylinder is seen to differ much in different species, becoming greater the higher the position of the animal. This increasing curvature is accompanied with increasing expansion of the roof bones of the skull and arrest of the basal bones: thus in the human subject the roof bones are expanded far more than in any other animal, while the basal bones are crowded and even fused together by their position in the concavity of the curve of the cylinder. The human curve is not complete in infancy; for, as the present writer has elsewhere shown, it goes on increasing for several years after birth: it is also greater in the higher than in the lower races of mankind. This curvature is an important means of increasing the space for the cerebral hemispheres, by lengthening the roof; and it does so most effectually when accompanied with the other means which Nature uses to expand the cranium, namely, increase of vertical and transverse diameter of the cylinder.

Further, before returning to the question of foreheads, it must be pointed out that the position in which the head is articulated with the neck differs in different persons, according to the weight of the fore and back parts, so as to preserve balance. This is best seen in the process of growth, for the forehead and face have the smallest proportional development in young children; and as they become large, the head is tilted further and further round on the top of the vertebral column, so as to throw more weight behind the point of support, to balance the weight in front: and this tilting takes place to a much greater extent in men than in women, because in women the face and forehead remain proportionally lighter.

From the foregoing considerations it must be apparent to everyone that loftiness of forehead results from general height of the whole skull, and that the apparent form of the forehead is very dependent both on the amount of total cranial curvature and on the balance of the head on the vertebral column. The deceptiveness of mere general appearance may, perhaps, be best illustrated by noting how people speak of the large foreheads of children. The frontal eminences of the child project forwards, and the head arches boldly above them, giving the appearance of a large forehead; but, in point of fact, the forehead of the child is proportionally very small and undeveloped; and its apparent prominence is due partly to the shallowness of the orbits, giving a comparative prominence to the frontal eminences, and partly to the whole skull being so set on the top of the spine that the forehead and face bones are turned more downwards than in the adult. The arch of the upper part of

the child's forehead is afterwards lost, because it is turned back to lie more level on the roof of the head. So also, in the female, the head being not so much tilted up, there is a persistent upward arching of the roof of the skull, as it is traced backward, which is peculiarly feminine and graceful.

With regard to development of the back part of the skull, it has been justly remarked by some good observers, that fulness of that region appears to be quite as important as a full forehead; and it is instructive to note, that if a sketch be made of a head in profile, a change of expression, ranging from almost idiotic weakness to great strength of character, may be produced by varying the outline of the lower occipital region and back of the neck, without altering any other portion. But the alteration of that line indicates not a mere addition to the posterior lobes of the brain or subtraction from them, but a change in the anatomy of the whole interior of the head, affecting the cerebral hemispheres throughout their extent.

So, also, those anatomists who have written as if the characteristic posterior lobes of the brain in man and apes were so much matter added to the back of the hemispheres, are really mistaken; for the hemispheres of a sheep rest against precisely the part of the cerebellum corresponding to that which they rest against in the human subject; but the human brain differs from that of the sheep in the vastly increased curvature and greater diameter of the cranial cylinder.

In bringing these cursory remarks to a conclusion, it is only necessary to add, that the reader is not to imagine, because it has been argued that different faculties are not localised in different parts of the cerebral hemispheres, that therefore it follows that there is no connection between the shape of the head and the mental character. Let the reader who still preserves a lingering fondness for judging men by their appearance continue to take the skull into account, if he pleases; but let him be assured that whatever connection really exists is to be explained, not by the phrenological dogma, but as he would explain why massive chins are often conjoined with strong wills, different types of hand with different types of mind, well-built frames with healthy mental tendencies, and rickety bodies with eccentric, though often keenest-witted natures. The explanation is physiognomical.

While, however, this is probably the case with regard to the shape of the head, it is obvious that the relationship of the amount of brain to the mental faculties is more than physiognomical. Possibly an analogy may be drawn between the brain and a galvanic battery, and increase of the grey matter of the one be correctly compared with addition to the cells of the other; but as in an electric instrument the working is de-

pendent on the delicacy and fitness of the arrangements quite as much as on the strength of the current which supplies them, so in the case of the mind the result is dependent on the distribution and balance of the faculties and inclinations, and on other circumstances, none of which are proved to have any connection with the mass of cerebral substance. Certain it is that, although there are probably mental characters peculiar to large and small brains respectively, the size of the skull is, as any observer may easily satisfy himself, no good guide to the mental endowments.

EXPLANATION OF PLATE.

FIGURES 1 to 5, adapted from various writers, illustrate the development of the BRAIN. i. ii. iii. are the primordial vesicles; *h* is the cerebral hemisphere; *c* the cerebellum.

FIG. 1. The cerebro-spinal canal nearly closed in a chick, after twenty-four hours' hatching.

„ 2. The embryo brain and spinal cord of a chick, after thirty-six hours' hatching.

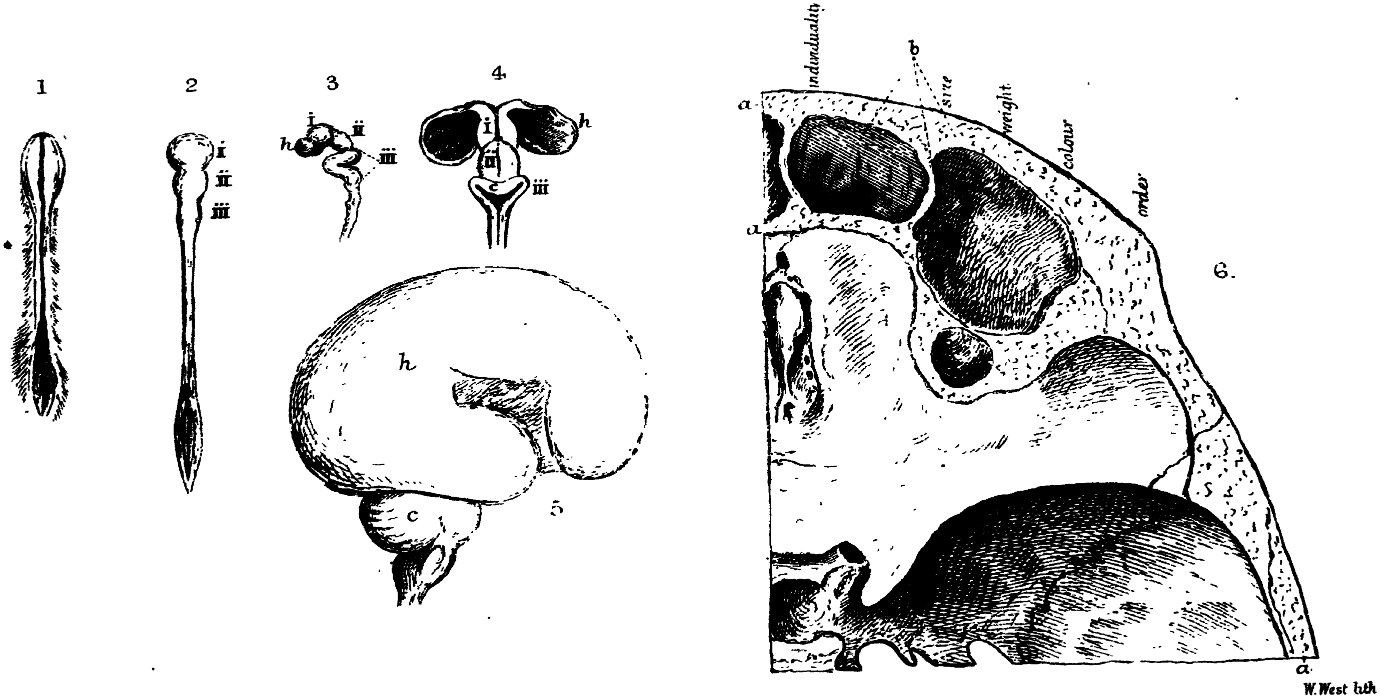
„ 3. Human brain at a very early period, seen in profile.

„ 4. A somewhat later style of development, viewed from above, and the hemisphere vesicles laid open.

„ 5. A considerably more advanced brain. The hemispheres have acquired their ultimate proportions, conceal the parts derived from the first and second vesicle, and rest on the cerebellum, but are not yet convoluted on the surface.

„ 6. Horizontal section of the fore part of the skull, through the right side of the forehead, half an inch above the orbital margin. *a a a.* The sawn edge of bone; *b.* section of the frontal sinus. It may be mentioned that in the fore part the sinus had considerable vertical depth, but that at the part farthest back on the roof of the orbit the depth is slight.

Plate LII


1
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W. West lith

THE ANATOMY OF A MUSHROOM.

BY M. C. COOKE.

[PLATE LIII.]

IF we accept the fact that about twenty thousand species of fungi have already been described, and in addition thereto venture to suppose that as many more have yet to be discovered, we shall be compelled to admit that fungi constitute no insignificant portion of the lower cryptogamic flora. If anyone should be disposed to question the probability of as many new species being discovered as are already known, we refer to the map of the world, and gain confidence in our belief. We know something of the fungi of Europe, but these are by no means exhausted; we know something of the fungi of a portion of the United States, but only of a portion; and of the rest of the world our knowledge of the mycologic flora is either exceedingly meagre, confined to a few of the larger and most easily preserved kinds, or we know absolutely nothing. Nearly the whole of Asia is, with the exception of limited areas, as the Sikkim Himalayas, Java, and Ceylon, unknown. Of South America we only know a portion of the large and easily preserved *Polyporei*. In Africa only Algeria, Guinea, and the Cape have yielded collections. In fact, the only portion of the world's surface which has been moderately well worked for fungi is certain parts of Europe, and even here the Spanish peninsula, Greece, Turkey, and all Southern Russia remain to be explored. In the face of these facts, we do not hesitate to pronounce that we know nothing of half the species of fungi now flourishing on the face of the earth.

Little as we know of the geographical distribution of these plants, little as we know of the species to be found over such large tracts as Central Africa, South America, China, Malayan countries, Northern Asia, and the Indian Archipelago, we find in all these places that some kinds of fungi are well known to the natives, and employed as food. It is not in Europe, or amongst the more highly civilised races only, that mushrooms

are appreciated; but even amongst the Australian aborigines, the natives of Tahiti, the Bhoteans of India, the Malays, and others, some fungus is sought after and devoured. It would be interesting to ascertain the extent of this fungus-eating propensity in the human race. At present our knowledge is limited to a few facts, and these sometimes without even a guess at the kind of fungus which is employed as food.

The large number of species to which we have alluded include an immense variety of forms. Between some groups of species and others there is as great a difference as between any two natural orders of flowering plants. In fact, the popular notion of a fungus, as typified in a "mushroom" or a "toadstool" applies only to a small proportion of the whole. Some are larger than the head of a man; others are smaller than the head of a pin. It is not easy to convince the casual observer of the affinity between truffles, puff-balls, blue-mould, and corn-mildew, or between all these and that privileged kind which bears the name, *par excellence*, of "mushroom," and is specially cultivated for the delectation of epicures. Yet these all constitute what some call a "class," and others an "alliance of orders," under the name of FUNGI.

Out of two thousand five hundred British fungi, there are at least five hundred of the "mushroom" type. By devoting a little attention to the structure and anatomy of this one species, therefore, we may hope to obtain a key to the structure of five hundred other and kindred forms.

The only fungus cultivated in this country is that known as the "common mushroom," or, botanically, *Agaricus campestris*, Fr. In the estimation of some, nothing else deserves the name of mushroom, no other merits an attempt at cultivation. This is a great mistake, which will be remedied, perhaps, some day. All who have attempted to grow even the "domesticated" mushroom (if such a term may be applied) know that it is useless to sow the spores, or water with the spores, or so employ the spores as they would the seeds of other plants, of which these would seem to be the analogues, in the hope of obtaining a crop. The seeds may be sown, but the plants are not produced. The reason for this fact is accounted for by another. Horse droppings, treated almost as seeds, realise in skilful hands an excellent crop. The explanation seems at least plausible and in accordance with the evidence. The spores of the mushroom will not germinate until they have passed through an animal. The horse becomes the medium; the spores are devoured, disjected, and, afterwards germinating in the excrement, appear to prove that the horse—or some such condition of heat and moisture as the stomach of the horse affords—is essential to the reproduction of mushrooms. The earliest condition in which

the plant is recognised as a vegetative entity is in that of "spawn," or, more accurately, as *mycelium.* This mycelium is essentially an agglomeration of vegetating spores. It is similar to the germinating threads of other fungoid spores; and to this entangled, anastomosing, branching, intricate network of delicate, slender, colourless threads is given the name of "mycelium." A mushroom may, like an orthodox sermon, be treated under three heads; for it resolves itself into three parts, viz., the *mycelium*, the *hymenophore*, and the *hymenium.* These are represented, in plainer and less technical language, the first by the "spawn," the second by the "stem and cap," the third by the "gills."

The *mycelium* has already been almost as fully described as necessary for the present purpose. Its normal form is that of branched, slender, hyaline threads, produced by the germination of the spores. An abnormal condition obtains in some instances in which the mycelium becomes compacted into a solid mass, at one time regarded as a perfect fungus, and constituted a genus under the name of *Sclerotium.* It is now admitted that a *sclerotium* is not a complete fungus, but only a compact mycelium, which may produce a perfect fungus, as in the case of *Agaricus tuberosus, Peziza tuberosus* and the ergot (*Sclerotium clavus*), which develops *Claviceps purpurea.* The mycelium of the mushroom does not, as far as we are aware, pass from the filamentous into the compact or sclerotioid form. We have termed the *sclerotium* an abnormal condition, which is scarcely accurate, since we only know *Claviceps purpurea,* for example, except as developed from this compact kind of mycelium; so that the sclerotium must be regarded as the normal, and not the abnormal, condition of the mycelium of that fungus.

The *hymenophore* is represented in the mushroom by the stem and the cap, or *pileus,* by which it is surmounted. This, with the mycelium, constitutes the vegetative system. At certain privileged points of the mycelium the threads seem to be aggregated and become centres of vertical extension. At first only a small, nearly globose budding, like a grain of mustard seed, is visible; but this afterwards increases rapidly, and other similar buddings, or swellings, appear at the base. As the young "hymenophore" pushes through the soil, it gradually loses its globose form, becomes more and more elongated, and in this condition a longitudinal section shows the position of the future gills in a pair of opposite, crescent-shaped, darker-coloured spots near the apex (fig. 2). In another and still more advanced stage the stem distinctly develops with a nearly globose head. The dermal membrane, or outer skin, seems to be continuous over the stem and the globose head. At present there is no external evidence of an expanded pileus and gills.

A longitudinal section at this stage shows that the gills are being developed, that the pileus is assuming its cap-like form, that the membrane stretching from the stem to the edge of the young pileus is separating from the edge of the gills, and forming a veil, which, in course of time, will fall away and leave the gills exposed (fig. 3). When, therefore, the mushroom attains almost to its maturity, the pileus expands, and in this act the veil, or membrane, extending from the edge of the pileus to the stem, is torn away from the margin of the cap, and remains for a time like a collar round the stem (fig. 6 *c*). Fragments of the veil often remain attached to the margin of the pileus, and the collar adherent to the stem falls back, and thenceforth is known as the annulus, or ring. We have in this stage the fully developed hymenophore; the stem, with its ring, supporting an expanded cap, or pileus, with gills on the under surface bearing the hymenium (to be described hereafter). A longitudinal section cut through the pileus and down the stem (fig. 6) gives the best notion of the arrangement of the parts and their relation to the whole. By this means it will be seen that the pileus (*d*) is continuous with the stem (*b*), that the substance of the pileus descends into the gills, and that relatively the substance of the stem is more fibrous than that of the pileus. More special details of the cell structure must be made out with the microscope. There are two or three features of systematic importance which may be observed by the naked eye, and these relate to the distinctions between the "mushroom" and other agarics.

The stem of the mushroom is not hollow or tubular as in some species, but continues to the centre, although less firm than near the circumference. When cut the surface immediately changes colour, and becomes brownish by a kind of oxidation caused by exposure to the atmosphere. In a transverse section of the stem this coloration does not take place in the centre, but a portion resembling the pith in the stems of some flowering plants remains white (fig. 10). The ring is very distinct, surrounding the stem, a little above the middle, like a collar. In some agarics the ring is very fugacious, or absent altogether. The cap or pileus is thick and fleshy, at first convex, and ultimately becoming almost flat in the centre, but not depressed. The gills are broad, widest near the middle and attenuated towards each end (fig. 6 *e*). Their inner extremity reaches, but is not attached to the stem. At first they are flesh-coloured and finally brown. All these features are of importance in determining the species to which an agaric belongs. The mishaps which accompany the eating of fungi, when they occur, may be traced to a negligence in regarding these particulars, especially the presence of the ring and the colour of the gills.

The whole substance of the mushroom is cellular. If, as

chemists tell us, more than ninety per cent. of a mushroom is water, the walls of the cells must be delicate and communicate freely. We know that fungoid growth is proverbially rapid. To obtain a tolerably accurate idea of the structure of the tissue of an agaric, it is advisable to slice off with a razor a thin longitudinal section from the centre of the stem. Such a slice will exhibit delicate tubular cells, the general direction of which is lengthwise, with lateral branches, the whole interlacing so intimately that it is difficult to trace any individual thread very far in its course (fig. 8). Another slice, taken in a similar manner transversely across the stem, will exhibit a much more porous character from the cut ends of the tubes being presented to the eye, mixed with branches or lateral cells. It will be evident that the structure is less compact as it approaches the centre of the stem, which in many species is hollow. Another section, taken in either direction from the pileus, shows that although the same type of structure prevails the cell walls are even more delicate, and it is more difficult to trace the course of the cells. There is a less distinct longitudinal direction, less pronounced fibrous character, and greater uniformity in density. Finally, a section across the gills (as at fig. 13) will show with a lens their relation to the pileus, but if a slice be taken from the cut face of one of the gills, a delicate, but by no means impossible operation, the central portion will be seen to be precisely the same kind of structure as the pileus, and indeed to be an extension of the pileus in plates, with the special cells of the hymenium growing from them on each surface (fig. 14). It may be observed here, that in order to the successful manipulation of fungi of this class, so as to obtain thin and satisfactory sections, it is essential that the agaric should be freshly gathered and cut while still firm, and before it has parted with any of its water. This caution is especially necessary if the weather is mild and dry.

A glance at the surface of the gills of almost any agaric will furnish the reason why they are nearly the same distance apart near the stem and near the circumference. Of course, if there were only one series of plates radiating from the stem, they would increase the distance between each other in proportion to their distance from the stem. This is obviated by a second, and a third, and even a fourth series, each shorter than the other, extending from the margin of the pileus inwards between the longer gills, so that the distance between gill and gill is nearly uniform over the whole of the under surface of the pileus. The arrangement is similar to the diagram given in the plate (fig. 4).

The *hymenium* is the spore-bearing surface. In puff-balls the hymenium is enclosed within the peridium, or external envelope, but in the mushroom it is exposed or naked, and spread

over the gills. Those plates which grow side by side, radiating from the stem, on the under surface of the pileus, or cap, of a mushroom are covered on all sides with a delicate membrane upon which the reproductive organs are developed. This is the hymenium of the mushroom. If it were possible to remove this membrane in one entire piece and spread it out flat, it would cover a very large surface, for it is plaited or folded like a lady's fan over the whole of the gill-plates or lamellæ of the fungus. It is this surface which is at first creamy, then pink, and ultimately purplish-brown, the colour being communicated by the myriads of spores produced upon it. If the stem of a mushroom be cut off close to the gills, and the cap laid upon a sheet of white paper, with the gills downwards towards the paper, and left there for a few hours, when removed a number of dark radiating lines will be deposited on the paper, each line corresponding with one of the gills. These lines are made up of spores which have fallen from the hymenium; if placed under a microscope their true character will be at once evident. Remove a fragment of the thin membrane carefully from one of the gills and place it on a slip of glass, then examine it with the microscope. The whole surface will be seen studded with spores (fig. 7). The first peculiarity which will be observed is that these spores are almost uniformly in groups of four together. The next feature to be observed is that each spore is borne upon a short slender stalk; finally, that four of these stalks proceed from the apex of a thicker projection from the hymenium, such projection being therefore the bearer of four sterigmata, or little stalks, each surmounted by its spore. Take one of the gills and place it flat on a slip of glass, and then examine the free margin of the gill, so as to obtain a view of the projections from its surface sideways: and by this arrangement the observer will discover on the hymenium two kinds of projections—one, the *basidia*, already alluded to, bearing spores; the other, *cystidia*, larger projections, without spores. These two kinds of bodies which are produced on the hymenium of most, if not all, the agarics, demand a still closer investigation. Before doing so it would be well to cut through the centre of one of the gills with a sharp razor, and from the cut surface to slice off a thin transverse section of the gill. By this process we shall discover that the cellular tissue of the pileus passes down the centre of the gills, that the cells are directed outwards towards the hymenium, that short cells intervene near the surface, and upon these compressed spherical cells the projections, or *basidia* and *cystidia*, are produced (fig. 14). There is no disjunction of the hymenium and the cellular structure of the hymenophore, but the former is a continuation of the latter. To speak or write of the hymenium, therefore, as a distinct

membrane is scarcely accurate, since it is composed of the apical cells of the threads which together constitute the hymenophore. It might be possible to isolate a thread from the mycelium, to trace it up the stem, through the pileus, down one of the gills to the surface, and there to support one of the basidia, with its four spores. During the course of such a thread the cells would be modified, sometimes elongated, sometimes shortened, and at length when reaching the hymenium, in some species, spherical, continually giving off lateral branches, and interlacing with the neighbouring threads, but maintaining a continuity through the whole structure, so that typically the whole mushroom may be regarded as a congeries of branched threads, bearing spores at their tips, consolidated together into one individual.

BASIDIA, or formative cells, are usually expanded upwards, so as to have more or less of a clavate form, surmounted by four slender points or tubular processes, each supporting a spore. (fig. 5 *b*). The contents of these cells are granular, mixed apparently with oleaginous particles, which communicate through the slender tubes of the sporophores, or sterigmata, with the interior of the spores. Corda states that although only one spore is produced at a time on each sporophore, when this falls away others are produced in succession, for a limited period. On this point we have no additional evidence. As the spores approach maturity the connection between their contents and the contents of the basidia diminish and ultimately cease. When the basidium which bears mature spores is still well charged with granular matter, it may be presumed that the production of a second or third series of spores is quite possible. Basidia which are wholly exhausted of their granular contents, and become hyaline, may often be observed. Seynes* observes on this subject, "If we could assure ourselves that amongst the tetrasporous basidia there are but two generations, each of four spores, that would show another affinity with the thecæ of the Ascomycetes, which produce, for the most part, eight spores."

CYSTIDIA are usually larger than basidia, varying in size and form in different species. They present the appearance of large sterile cells, attenuated upwards, sometimes into a slender neck (fig. 5 *c*). Corda was of opinion that these were male organs, and gave them the name of *pollenaire*. Hoffmann † has also described both these organs under the names of *pollinaria* and *spermatia*; but he does not appear to recognise in them the sexual elements which those names would indicate, whilst Seynes recognises

* "Essai d'une Flore mycologique de la région de Montpellier et du Gard," par J. de Seynes. Paris, 1863.

† Die Pollinarien und Spermatien von *Agaricus* in "Botanische Zeitung," 29 Febr., 7 Mar. 1856.

them, and suggests that the cystidia are "only organs returned to vegetative functions by a sort of hypertrophy of the basidia." This view is supported by the fact that in the section *Pluteus* the cystidia are surmounted by short horns resembling sterigmata. Hoffmann has also indicated the passage of cystidia into basidia (*Bot. Zeit.* 1856, pp. 139). All the evidence seems to be in favour of regarding the *cystidia* as barren conditions of *basidia*.

There are in the hymenium a third kind of elongated cells, called by Corda* "basilary cells," and by Hoffmann "sterile cells," which are either equal in size or smaller than the basidia, with which also their structure agrees, excepting in the development of sterigmata (fig. 5 *a*). These are the "proper cells of the hymenium" of Léveillé, and are simply the terminal cells of the gill structure—cells which, under vigorous conditions, might be developed into basidia, but which are commonly arrested in their development. As suggested by Seynes the hymenium seems to be reduced to great simplicity: "one sole and selfsame organ is the basis of it; according as it experiences an arrest of development, as it grows and fructifies, or as it becomes hypertrophied, it gives us a *paraphyse*, a *basidium*, or a *cystidium*, in other terms, atrophied basidium, normal basidium, hypertrophied basidium: these are the three elements which form the hymenium."

The presence of male organs, or antheridia, or anything analogous thereto in the mushroom, and in fungi of the mushroom type, has yet to be demonstrated. Hitherto all efforts to discover them appear to have failed. The only reproductive organs, therefore, with which we have to deal are the *spores*. These are sometimes called *basidiospores*, because they are borne at the summit of the cells termed basidia. It has been noticed already that they are tetrasporous, that is, they are produced in groups of four to each basidium. The spores are at first colourless, in some species they remain so, in others they pass to some shade of brown. The variety of tint, form, and size of the spores of agarics is so great that it would be difficult to enumerate. Anyone desirous of studying them can do so with little trouble by placing the pileus of fresh specimens, gills downwards, on slips of glass, and protecting the spores so obtained by thin covers, in the usual way. The spore envelope is considered to be composed of two membranes—the external, or more tenacious, being the *exosporium*, and the internal, more delicate, the *endosporium*. It is always the external membrane which is coloured. The spore contents are the same as those of

* "Icones Fungorum hucusque cognitorum." Tomus iii., p. 41. Pragæ, 1839.

the basidia, and pass from the latter to the former through the slender tubular sterigmata during the growth of the spore. At first the apices of the sterigmata swell and assume the form of small, round tubercles. For a long time the spherical shape is maintained, but at length the form peculiar to the species, whether ovoid, elliptical, angular, or cylindrical, is established, and in some kinds the surface is covered with asperities, whilst in the majority it is smooth (fig. 9).

When the spores are mature their colour is comparatively constant in the same species. So much is this the case that the colour of the spores is employed to divide the different species of agarics into five groups or series. In one of these the spores are colourless, or white when seen in a mass. In another they are salmon-coloured. In a third series they are rusty, tawny, or brownish. In a fourth—to which the common mushroom, and the meadow mushroom (*Agaricus arvensis*) belong—the spores are of a brownish-purple or brown. And in the fifth series they are black, or nearly so. The spores being matured fall from the basidia upon the ground beneath the pileus. So profuse are the spores in some species, that, especially when white, they seem wholly to cover the surface immediately beneath. That very common species (*Agaricus melleus*), which grows in large tufts on old stumps, is a familiar example of the profusion of spores which may be evolved from a single fungus. In this instance the ground, or any intervening object, is rendered as white as if sprinkled with flour or powdered lime.

The most obscure period in the life history of an agaric, and some other fungi, is that which intervenes between the mature spore and the young plant. We see the spores fall to the ground in profusion: from myriads of spores perhaps the same spot does not the next season supply us with a single fungus. We collect the spores of species after species, and try by all known processes to force them to germinate, but it is fruitless. Their behaviour is, to all appearance, that of unfertilised ova, of unimpregnated germs. What are the conditions which agarics require in order to render their spores fertile? We know something of one species, and of one only; but even that is accidental, and we cannot give a logical reason. The great difficulty in the way of cultivating other esculent species is that of ascertaining the requisite conditions for the germination of the spores. Here is a good field for investigation and experiment, and there is no doubt that if persevered in such efforts would produce results calculated to bring us nearer to the comprehension of this mystery, which is at present wholly a mystery, such as involves no other members of the vegetable kingdom. It is possible that spermatia may yet be traced where they are

now least suspected. No one was prepared to expect zoospores in the conidia of white rusts (*Cystopus*), or in the oospores of the parasitic moulds (*Peronospora*) until De Bary's investigations set the matter at rest. Such a complex method prevails in some fungi, as in Bunt (*Tilletia caries*) an alternation of generations, that we may even suppose that it is not more simple in agarics. Curious instances of conjugation have also been discovered, as by De Bary* and Tulasne,† bringing the mode of development more into harmony with what has been observed in the lower algæ. Something analogous to this is detailed by Professor Karsten,‡ as having been observed by him to take place on the mycelium of the common mushroom and *Agaricus vaginatus*. He says, "In *Agaricus campestris*, by gradually going back from the forms recognisable with certainty as the youngest states of the cap to smaller ones, I found an organ which, from its peculiar form and texture, I could not but regard as the first commencement of the fruit. This was an oval, almost egg-shaped, simple cell, standing upon a short peduncle of the thickness of the mycelium, and of from three to four times the diameter of this, filled with albuminous matter and overgrown by filaments of the mycelium, which were at first single, but by continually increasing in number, at last form a thick rind (*peridium, velum*) over the central ovicell, which, in the meantime, increases in size." In *Agaricus vaginatus* he found similar bodies (fig. 12), and beside them cylindrical cells springing from the mycelium. In one instance this cylindrical filament consisted of two cells, the upper of which contained a turbid fluid. This upper portion was in contact with the oval cell, so that it seemed to be pressed into the latter, and amalgamated with it at the point of contact (fig. 11). Karsten names these stalked ovoid cells *archegonia*, and concludes that the conjugation of these two bodies, the cylindrical with the ovoid, is a fecundative process, similar to what he had described as taking place in a lichen (*Cœnogonium*). At present these observations have not been confirmed, and it would be idle to speculate upon their value, or to accept them as an elucidation of the mystery of germination. If we admit Karsten's theory, it has still to be shown what are the conditions under which these two forms of cells are produced. The germination of the spore and growth of mycelium is the

* "Annales des Sciences naturelles." Série V: Botanique. Vol. v. p. 343, ann. 1866. "Morphologie und Physiologie der Pilze etc." Leipsic, 1866.

† Note sur les Phénomènes de Copulation que présentent quelques champignons. "Ann. des Sc. nat." Série V: Botanique. Vol. v. p. 211. 1866.

‡ "Botanische Untersuchungen," 1866, pp. 160–169. Translated in "Ann. and Mag. of Natural History," Series iii. vol. xix. p. 73. 1867.

subject which requires elucidation, and when we have ascertained the mode of growing agarics of any species, *ad libitum*, from the spores, it will be comparatively easy to determine whether a kind of prothallus is formed on which germ and sperm cells are developed, as in some other cryptogams, or whether the plant at once rises from the mycelium without any such intervention.

EXPLANATION OF PLATE.

FIG. 1. Young mushrooms (*Agaricus campestris*) springing from the mycelium or spawn.

,, 2. Longitudinal section of young mushroom with indication of future gills.

,, 3. Longitudinal section of mushroom in a more advanced condition.

,, 4. Diagramatic sketch of portion of the hymenium of mushroom, showing arrangement of the gills.

,, 5. Fragment of hymenium of an agaric (*Gomphidius*), showing *a* sterile cells, *b* basidia, *c* cystidium, magnified highly.

,, 6. Longitudinal section of mature mushroom (*Agaricus campestris*), *a* mycelium, *b* stem, *c* veil or ring, *d* pileus or cap, *e* gills, covered with the hymenium.

,, 7. Portion of hymenium of meadow mushroom (*Agaricus arvensis*), seen from above, with the spores *in situ*, magnified.

,, 8. Portion of stem of mushroom, highly magnified.

,, 9. Spores of mushroom (*Agaricus campestris*), more highly magnified.

,, 10. Transverse section of stem of *Agaricus campestris* with its pale, pith-like centre.

,, 11. Archegonium and cylindrical branch-cell from *Agaricus vaginatus*, highly magnified. After Karsten.

,, 12. Two naked archegonia from the same agaric, highly magnified. After Karsten.

,, 13. Transverse section of gills of mushroom.

,, 14. Transverse section of gill of mushroom (*Agaricus campestris*), showing arrangement of hymenium with its basidia and spores, and central cell-structure descending from the pileus, highly magnified.

THE CHEMISTRY OF A COMET.

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THERE are few facts in modern science more marvellous than that of the application of certain optical properties of gases to the determination of the materials of the sun and fixed stars. But perhaps the application by Professor Tyndall of some chemico-optical phenomena to the elucidation of the nature of cometary matter is no less remarkable. In the belief that the experiments and speculations of our distinguished physicist on this subject are as yet but imperfectly known, we propose to give some account of them in the following article.

The reasons which require us to regard the cause of cometary phenomena to be a material substance are two. In the first place, a comet pursues a path the direction of which has been proved to be such as would result from the attractions of the sun and planets for a mass having a certain momentum. Secondly, the light of a comet has been shown to be reflected light received from the sun, inasmuch as that it is *polarised* light, and that it weakens or intensifies as it respectively removes from or advances towards the sun; for the light of a *self-luminous* body is never found to be polarised, and it does not alter in intensity or brightness as we move off from or approach the body, the variation in the quantity of light received being solely proportionate to the variation in the apparent size of the body by distance.

But the acceptation of the theory that a comet is constituted of matter has presented great difficulties because of its properties and behaviour. Thus, if as matter a comet reflects light, its reflecting power has hitherto seemed to be utterly out of proportion to its power of intercepting light, according to our knowledge of all terrestrial matter. For while a comet may be visible in broad daylight (in consequence of the light it reflects),

any thickness of its substance, say 100,000 miles of it, proves to be quite *transparent* to the light of the stars, and has not, therefore, the opacity of a puff of steam or smoke. This apparent anomaly in its properties as matter is seen in a more exaggerated form in the fact that a comet has not a *dark side* to it—it presents no *phases*: measuring even hundreds of millions of miles in a line from the sun, the rays of this luminary pass *right through* such a vast extent of matter without being extinguished, and illuminate its remote parts; hundreds of millions of miles, therefore, of matter, in the condition to reflect light, is yet nearly or, for aught we know, quite transparent.

Another great difficulty lies in the apparent motions of the tail of a comet. In receding from the sun, as is well known, the tail of a comet is *in advance* of the head, although in advancing to it the tail is—in the position it ought to have to be called a tail—*behind* the head. The tail, therefore, swings round the head at the time of its passing through its perihelion. In the case of the great comet of 1843, its tail, many millions of miles long, swung round half a circle in little more than two hours! Can we help feeling the incredibility that a *material* tail could have acquired and move with such a velocity, and this not by the aid of, but in opposition to, the attraction of the sun? Indeed, it is impossible to admit both the fact of such a motion and the materiality of the tail, without attributing to the matter of the tail peculiar and improbable properties not possessed by terrestrial matter.

The apparent motion of the substance of the tail into and out of the head of the comet is hardly less difficult to understand, if the tail has really substance. For example, according to Newton, the great comet of 1680 shot out, after passing through its perihelion, a tail in two days, sixty millions of miles long! Can we admit, without the most conclusive evidence, that that which, starting from a state of relative rest, as regards, that is, the head of the comet, acquired a velocity which carried it such a distance in such a time, was matter as we know it here? Even if we can, we must suppose an almost equally inconceivable repulsive force to drive it out in such a way; so that we are little better off. Kepler, we believe, advanced an hypothesis of a repulsive force to account for the growth of the tail, and Sir John Herschel has also expressed his conviction that some such force must exist in the sun for the matter of the tail. He has suggested that the sun's rays chemically decompose some of the matter of the head of a comet into *gravitating* and *levitating* matter—that is, matter attracted by the sun and matter repelled by it. Indeed, he has even said of comets, that among the uses they have served, is that of having "furnished us with a demonstration of the existence of a repulsive force, directed

(under certain circumstances, and acting on certain forms of matter) from the sun." The truth of this demonstration is in a high degree improbable, even when not viewed in the light which Dr. Tyndall's researches have thrown upon the nature of cometary phenomena; and, from the interest Sir John Herschel has taken in these researches, from the full recognition he has had of the profound difficulties of cometary theory, and from his admirable perception that cometary phenomena were of just that kind that they would be were some such reactions of matter possible as those discovered by Dr. Tyndall, we make no doubt he no longer holds to his assertion that cometary phenomena demonstrate the existence of levitating matter.

Notwithstanding the difficulties there have been felt to be in interpreting the behaviour of a comet as that of a material substance, they have not been deemed sufficient to invalidate the claims of comets to rank as material bodies. These claims admitted, in what state or physical condition it exists is the next matter for inquiry. The answer to this has been tolerably clear, and this is, that it is in the state of *mist* or *cloud*. And here, as it is essential to the clear understanding of Professor Tyndall's cometary theory that the distinction between "mist" or "cloud" and "vapour" is thoroughly recognised, it will be well to state these distinctions. A "vapour" is a gas which can be made to assume the state of liquid by cooling it, and being a gas, its particles are homogeneous and tend to separate from each other. A "mist" or a "cloud" is a gas in which are suspended minute particles of liquid, and its particles are therefore heterogeneous. The consequence of this composite nature of mist is, that it intercepts rays of light cast on it, and reflects them; surfaces of separation such as occur between its liquid and solid particles being the condition for reflection. In other words, a mist shines and is visible when light is thrown on it; and this is a property not possessed by true vapours or other gases. Now, as the matter of a comet is obviously of a gaseous nature, there can be no hesitation in deciding that it is in the form of mist, because it is luminous, not of itself, but in the rays of the sun. The only difficulty that has been hitherto felt, has been its unparalleled transparency, already referred to. The shrinking which is observed to occur in the head of a comet when it approaches very near to the sun, is quite in accordance with what is to be expected if the comet is a mist or vast cloud, the heat of the sun converting its outer portions of liquid particles into (invisible) vapour, and, being absorbed by so doing, not reaching the central portions.

Such being the state of cometary theory, Dr. Tyndall has brought to bear upon it the knowledge we have gained of natural phenomena, by some exceedingly beautiful researches lately

made by him. He has almost entirely removed all the difficulties in the way of accepting the material constitution of comets, by showing that the properties of cometary matter are not peculiar to it, but common to terrestrial matter, and are sufficient to explain all its appearances. "Throughout this theory," to use his own words, he "has dealt exclusively with true causes, and no agency has been invoked which does not rest on the sure basis either of observation or of experiment." Before we can proceed, however, to the consideration of Dr. Tyndall's elegant theory, we must give a brief account of that part of his researches on which it is based.

He has found that the rays of the sun, or of the electric light, possess the property of generating a mist or cloud, in certain vapours mixed with gases, and that such a mist in a state of extreme tenuity possesses peculiar optical properties, similar to those shown by the visible matter of a comet. One mode of exhibiting the formation of this cloud is as follows:—A glass tube is taken, about three feet long and three inches in diameter, closed at the ends by glass plates, and having a lateral opening by which it can be charged or emptied. This is so arranged in a dark room that a beam of light from an electric-lamp can be sent through it at pleasure. The tube is exhausted of air by the air-pump, and then air, or some simple gas such as hydrogen, oxygen, or nitrogen, is allowed to flow in, charged with the vapour of some selected liquid. The charging of the air or gas with the vapour is accomplished by allowing it to bubble through the liquid yielding the vapour, or to pass through a pellet of paper or cotton moistened with the liquid. When the electric light is sent through the tube, the contents are at first invisible, and continue so if the air or gas has not been charged with a vapour, and has been freed from motes. But in the presence of certain vapours, a *cloud* begins to form in a very short time. If the tube is fully charged with air loaded with the vapour, the cloud begins to form almost instantly, and assumes a white colour. But when either by allowing a very little only of the air saturated with this vapour to enter the exhausted tube, or by filling the tube with air charged with the merest trace of vapour, such as it obtains by passing through a pellet of bibulous paper barely damped with the liquid, a highly attenuated vapour is made to fill the experimental tube, the production of the cloud is much slower, and its appearances are different. It is at first of a beautiful sky-blue colour, and only gradually changes to white. It begins to form in the vapour next to the light, and then gradually extends through it to the remote end of the tube.

The appearance of the cloud or mist in the tube is evidence of the formation of particles of liquid—indeed, when the tube

has been freely charged with the vapour, these particles can be seen under a magnifier. This liquid must be a product of some chemical change of the vapour, and partial evidence of this change has been obtained by Dr. Tyndall. But it does not of course follow that because rays of light cause a chemical change in a vapour that a cloud must form. This formation involves the further condition, that one, at least, of the substances produced by the change shall have a vapour of such low tension at the temperature of the tube, as that, its point of maximum density being soon reached, the rest of it precipitates in the liquid form. Hence, the more attenuated the vapour with which the tube is charged, the slower the cloud of the substance produced by the change is in forming; the first formed portions of the substance preserving the state of (invisible) vapour, and the cloud beginning to form only when the point of maximum density of the vapour is reached. This is further shown by the fact that the cloud begins to form in the vapour next the light, and then extends from it, with a velocity depending upon the quantity of the vapour present.

The chemical change which is the cause of the formation of the cloud is due to those rays of light which are active in causing other chemical changes, such as those upon which photography, sun-bleaching, &c., depend. In proof of this, Dr. Tyndall found that the rays of the electric-lamp were equally effectual in causing the clouds after the heat-rays had been intercepted by passing the beam through a solution of alum (which absorbs heat-rays without affecting luminous rays). Further, by passing the light through red, yellow, and blue glasses, he found that the first two intercepted most of the rays capable of bringing about the change, and that the blue glass did not do so. The blue rays, and those beyond them in the spectrum—that is, the most refrangible rays—are those which have hitherto been found to be those in which principally reside the power of causing chemical changes.

Now, to return to the optical properties of these actinic clouds. The weight of substance sufficient to form a luminous white cloud is of the utmost minuteness. For example, Dr. Tyndall took a small bit of bibulous paper, rolled it up into a pellet not the fourth part of the size of a small pea, and moistened it with a liquid possessing a higher boiling-point than that of water; he held the pellet in his fingers till it had become almost dry, then allowed dry air to pass over it in a connecting piece into the tube for a preliminary experiment; this experiment over, the pellet of paper was removed, and a current of dry air passed through the connecting piece and experimental tube; then, through the same connecting piece, hydrochloric acid gas was passed into the tube, and found, in its

passage, enough in what, after this treatment, was left in the connecting piece, to form a cloud in the light of the electric-lamp, which at the end of fifteen minutes discharged a body of light that, "considering the amount of matter involved in its production, was simply astounding." With this property of reflecting light, it possessed that of being apparently perfectly transparent. Thus, a page of print illuminated by it lost none of its distinctness by being viewed through the cloud itself.

We are now prepared to consider Dr. Tyndall's interpretation of the nature of cometary matter. According to him, a visible comet is formed of parts of a mass of gas or vapour of extreme tenuity, which become visible to us through a chemical change induced in them by the sun's rays, this change having amongst its products at least one substance incapable of preserving the state of vapour at the temperature of the comet, and, therefore, precipitating as a cloud of liquid spherules in the rest of the mass of vapour. Sir John Herschel estimates the weight of a great comet as lying between a few ounces and a few pounds, and Dr. Tyndall feels satisfied, by the experiment we have described, in which an inappreciable trace of vapour gave a white luminous cloud, by the light of which a printed page could be read, that a few ounces of one of the substances he used (the iodide of allyl), converted into vapour and sufficiently attenuated, would be quite enough to furnish in the sunbeams a cloud of the magnitude and luminosity of Donati's comet—that is, about thirty millions of miles long and about ninety thousand miles thick. Like the luminous matter of a comet, too, this actinic cloud would be transparent, and allow, therefore, of the stars being seen through it.

Let us first employ this theory to explain the formation of the head of a comet, or, in the case of the comets without tails, of the entire visible comet itself. Conceive the cometary mass as a vast body of exceedingly attenuated vaporous matter, which becomes denser towards some more or less central point, but still not to such an extent as to deprive it of its highly attenuated character. Such a condition may be the result of the gravitating action of the small solid nucleus which some comets have appeared to possess, or it may be the result of a slight attraction existing between the particles of such highly attenuated vapour. As the sun's rays pass through this mass of vapour, they effect a chemical change, the products of which are visible as a cloud at the denser part of it, because the cloud-forming portion of them is here in greater quantity than can exist in the state of vapour at the temperature of the comet. In the rarer, outer parts of the mass the chemical products are not in greater quantity than can maintain there their vaporous condition.

Now, with regard to that marvellous phenomenon, a comet's

tail. In his "Outlines of Astronomy," Sir John Herschel, writing of the motion of comets' tails, says, "If there could be conceived such a thing as a *negative shadow*, ... this would represent in some degree the conception such a phenomenon irresistibly calls up." The researches on which the new cometary theory is based show that we can do so, such a conception being fully justified by the physical facts now brought to our knowledge. Suppose for a moment, in opposition to actual observation of comets, that in the sun's rays the head of a comet cast an ordinary or "positive" shadow. Then, wherever the comet moved, its shadow—like its tail—would always point away from the sun; and when the comet passed through its perihelion, this shadow would be cast from the central cloud, or head, round upon the surrounding parts of the comet, with all the angular velocity actually shown by a comet's tail at this period. The rapid motion of a comet's tail round the head would therefore not be in the least degree strange, could the tail be taken to be not a thing of substance, but merely the shadow of the head. But we know that our supposition is contrary to fact. Suppose, however, the following modification of it. Give to the head of a comet the property of absorbing, not the *illuminating* rays of the sunbeams, but the *heating* rays, and it would throw, instead of (what we will call) a *light-shadow*, a *heat-shadow*. Further, let it transmit, besides the illuminating rays, any excess of *chemically-acting* rays over those used-up in causing changes in its own substance. Under these circumstances, a "negative" shadow, that is, an illuminated shadow, instead of a dark shadow, would be formed, and the luminous comet's tail, so wondrously shadow-like in its motions, would no longer be a mystery to us. In the cometary theory of Dr. Tyndall such suppositions are made, and, be it remembered, in full accordance with known facts. Thus, when, as is so often done for experimental purposes, a glass vessel of solution of alum is placed in the rays of the sun, the heating property of the rays is removed by the solution, while the chemical and illuminating properties pass on. Similarly, the luminous property can be withdrawn from the rays, and the heating property left to them by substituting for the aqueous solution of alum a solution of iodine in carbon disulphide.

The head of the comet, being admitted to cast a *heat-shadow*, will keep all that portion of the cometary vapour on the side of it away from the sun at a much lower temperature than the portions which do not lie in this shadow: hence, when in these portions none of the products of the chemical change wrought by the sun's beams are precipitated as spherules of liquid because they are so heated, in the portion lying in the *heat-shadow* some of these products may assume the liquid state, and form a

cloud. If so, *this would be visible in the sun's illuminating rays*, and present the appearance of the comet's tail.

By the change which takes place in the relative position of the sun and the head of the comet, the *heat-shadow* moves over the surrounding cometary vapour, and, as it does so, leaves behind it parts that were just before within its area, and receives, as it advances, parts previously exposed to the heating action of the sun. Whilst, therefore, near the advancing side of the shadow, fresh cloud is being formed by the cooling of the previously heated vapour, the cloud left behind by the shadow is being dissipated by the action of the heating rays of the sun received by it. This formation and dissipation of the cloud being a process of time, the luminous cloud will lie a little behind the *heat-shadow*; and as that part of the cloud just emerged from the shadow which is nearest the sun will first, and to the greatest degree, receive the heat, it will be the first dissipated, and thus give rise to a *curve* in the cloud. Hence, the observed facts that the tail of a comet is generally curved and inclined to the side of the region just left by the comet. At the period of passing through its perihelion, half the circumference of the cometary mass is traversed by the heat-shadow with all the velocity observed in a comet's tail. When the volatility of the chemical product is very slight, and its quantity sufficient, this shadow may keep up the existence of a tail-cloud; in other cases, the heat of the sun dissipates the tail entirely for the time. The enormous velocity with which, as the heat-deprived sunbeams are cast into fresh portions of vapour, the comet's tail *grows* after the perihelion passage of the comet, is such as would be imitated by the growth of a chemical cloud under suitable conditions, according to Dr. Tyndall. Lastly, with regard to other peculiarities in the tails of comets, they would none of them probably afford any difficulty in accounting for them had we a little more intimate acquaintance with the constitution of individual comets. Thus, as the distinguished propounder of the theory suggests, "in the struggle for mastery of the two classes of rays [heating and chemical], a temporary advantage, owing to variations of density, or some other cause, may be gained by the actinic rays, even in parts of the cometary atmosphere which are unscreened by the nucleus. Occasional lateral streamers, and the apparent emission of feeble tails towards the sun, would be thus accounted for."

The theory we have now laid before our readers, that a comet is a *chemical cloud*, is at present without doubt open to material criticism, but we feel a strong conviction that its general soundness will be fully confirmed by time and further investigations.

REVIEWS.

ENTOZOA.*

THE strides which natural science makes from year to year are so vast that even in a small department like that of the study of Entozoa, it is found that what is written to-day, be it never so complete, will not be *en rapport* with the state of science two or three years hence. Dr. Cobbold, who a few years ago gave us his splendid monograph on the Entozoa, has realised this fact; and, in accordance with the wants of naturalists, he has issued a supplement to his former treatise in the volume now before us. But this new work has a value apart from its supplementary character. It contains a mass of very useful and interesting facts, which may be read quite distinct from the earlier treatise. Of this nature is the author's chapter on the history of the discovery of *Trichina spiralis*. Perhaps in the whole of the recent history of internal parasites. there has been no creature which has been regarded with more interest or terror than the little flesh-worm which is called *Trichina*, and which threatened to do so much mischief among our Teutonic neighbours some time ago. This nematoid, which is to a certain extent microscopic, and which is to be found occasionally in myriads in pork, and even in the bodies of raw-pork-feeding human beings, is essentially a native of Germany. Yet, singularly enough, it was first discovered in this country. But the question who was its discoverer, was one which, while it excited much controversy, it was impossible to answer definitively, till Dr. Cobbold inquired into the matter, and gave us the decisive reply which his chapter on the subject expresses. The author has been at great pains to go through all the literature relating to the discovery of Trichina, and we think his conclusions, which are formulated in nine separate propositions, may be accepted as final. The first of these is that "Mr. Paget first actually determined the existence of the parasite, which was subsequently more completely described by Professor Owen. Mr. Paget was assisted in the discovery by the celebrated botanist Robert Brown, who lent his microscope for the purpose of examination." The other "conclusions" state that Professor Owen first scientifically described the worm, that Mr. Wormald supplied him with the specimens, that Mr. Hilton first suggested the parasitic character of the worm, that Herbst was the first to rear the worm experimentally,

* "Entozoa. Being a supplement to the Introduction to the Study of Helminthology." By T. Spencer Cobbold, M.D., F.R.S. London: Groombridge. 1869.

that Leuckart first fully described its mode of genesis and development, and lastly, that Zenker first showed that the ingestion of the worm gives rise to a series of very fatal symptoms—in fact, to a disease.

The great bulk of Dr. Cobbold's supplement embraces his account of a multitude of experiments made with different entozoa, with a view to discover the effects both as to the development of the particular parasite and as to the position in the animal tissues in which it becomes lodged; those on the Trichina being of most importance, both from the grave character of Trichiniasis, and from the fact that the results were on the whole very conclusive. But there is also much information of a general character in regard to other entozoal points, and especially in reference to the peculiar gregarinida or psorospermiæ found in cattle killed by cattle plague, and which were, at the time of the Rinderpest invasion, described and figured in these pages by Dr. Lionel Beale.

The chapter which the philosophic naturalist will read with most pleasure, is the last one, in which Dr. Cobbold expresses his views on the question of organic individuality from an entozoal stand-point. Those who have read Dr. Quatrefages' charming work on the "Metamorphoses of Man and the Lower Animals," * will remember that the whole of the phases which an animal presents from the period of leaving the ovum (or, as Van Beneden and Sars have shown, even before leaving the egg) till it has arrived at sexual maturity, must be included within the term individual. They are all, in fact, but one being, the different stages being technically styled zooïds. Now different methods of classification have been adopted for the purpose of conveniently grouping these stages together to the framing of certain analogies, more fanciful than real. Dr. Cobbold strikes out a new path, and proposes a novel or somewhat novel mode of arranging the developmental phases of Entozoa. His plan is simple, and has doubtless certain advantages, but we dissent from it simply on the principle that all such methods of grouping are valueless in so far as the extension of philosophy is concerned, and have only this one merit, that of being *methodic*. Let us, however, place Dr. Cobbold's scheme briefly before our readers, and allow them to judge for themselves. It is proposed by the author to call each successive life-epoch in the history of an entozoan, whether it be "distinctive or indistinctive, separable or inseparable," a biotome. Further, when there are more than one of such biotomes, he distinguishes them by the terms primary, secondary, tertiary, &c. Taking *Tænia serrata* as an example, we get the following plan:—

Zoological individual (*T. serrata*)

a Ovum in all its stages *b* Six-hooked larva or pro-scolex *c* Resting larva scolex or *cysticercus pisiformis*	Primary Biotome.
d Sexually immature tape-worm in all stages *e* Mature tape-worm colony, strobile or *Tænia* *f* Segment, free-joint, or proglottis (Zoöid)	Secondary Biotome.

* Published by Hardwicke.

Such is Dr. Cobbold's idea, only imperfectly explained. Readers must consult the book itself for all the outline arguments. But in the meantime we must say, we do not see what advantage the new terminology has over Huxley's proto- and deutero-zooids, or indeed those over the old Strobila scolex and proglottis. Are not all, to a certain extent, objectionable, for the manner in which they ".trammel up" our ideas?

Ere we conclude our notice we must say a word of praise of the more purely editorial features of this volume. The index of authorities, general index, and supplemental bibliographical list, are most copious, and have been carefully prepared and arranged.

BRITISH MOTHS.*

A GREAT many of the younger members of the modern school of zoologists look down on the study of insects as an over-wrought field, which has ever been barren of anything but an appalling list of species. This is a most egregious mistake; and we trust that the publication of so excellent a volume as that which Mr. Newman has now issued will help to dispel this false notion, and popularise a love of this branch of entomology among the better class of rising naturalists. As the author very fairly states, our works of reference on the moth family are most imperfect; and we cannot help thinking he is right in attributing this to the circumstance that many of those who have prepared treatises while they have been tolerably conversant with the imago or perfect form, have not been so well acquainted with the larva and pupa, and hence have often erred in their diagnosis. Another explanation is that the descriptions have not seldom been taken from foreign books, and therefore errors have been committed of the most confusing kind in the matter of terminology. These defects are obviated fully in Mr. Newman's work. The author has, so far as was possible, described and figured the British moths from actual specimens both of larva and perfect insect, and by this means he has avoided the mistakes of his predecessors.

Mr. Newman complains that, much as has been the attention devoted to the moths, the system of classification is still imperfect. Here there is a field for the young naturalist who will study the whole group in all its stages, and devise or hit upon a natural method. The scheme of division he adopts is that of the four sections, Nocturnes, Geometers, Cuspidates, and Noctuas, the several families being arranged under these and the genera, species, and varieties following in the proper order. In all cases, whether of groups or of varieties of species, the author's descriptions are really painstakingly simple. Technicalities are, to a wonderful extent, avoided, and no effort is spared to make the account intelligible even to those who have never taken a scientific work into their hands. Thus it seems to us that an intelligent

* "An Illustrated Natural History of British Moths, with life-size Figures from Nature of each Species, and of the more striking Varieties." By Edward Newman, F.L.S., F.R.S.A. London: Tweedie. 1869.

reader should be able to "diagnose" a species by the aid of the mere verbal description given by the author. But should he fail to do this, then he will find a royal road in the excellent woodcuts intercalated in the text, and which "make assurance doubly sure."

Not only is each species depicted in an excellent illustration, but, in many cases, even varieties are figured. In point of typography the work leaves nothing to be desired. In conclusion, we can only say that if any of our young readers desire to cultivate their powers of observation by the study of a most attractive and easily accessible order of animals, they should at once make themselves familiar with Mr. Newman's handsome and accurate treatise on the *British Moths*.

THE ANIMALS OF THE BIBLE.*

WHO does not wish to know what zoologists think anent the creatures mentioned in the Bible? Who has not some doubt as to whether the translators of the Bible have—with their limited knowledge of zoology—correctly interpreted the meaning of the original? To all such, Mr. Wood's attractively-named volume will furnish a fund of highly instructive and interesting matter. The plan of the author is simple enough, and it has been carried out with considerable fidelity. He has "searched the Scriptures" for the names of animals, and having noted the different passages which refer to these, he has grouped them together under their several heads, and has then given a popular sketch of our present knowledge of the creatures in question, and of the labours of those who have compared the original Biblical name with the name of the animal in various Eastern tongues. The order he adopts is the zoological one, and is partly expressed in the title, in which he tells us that he has travelled over the whole series, "from the ape to the coral."

We would have it distinctly understood that Mr. Wood's sketch is eminently a popular one. It in many cases omits important details, and, in some cases, lays down what would appear to other writers very questionable conclusions. But the *tout ensemble* of the work is pleasing, and, indeed, good; and the illustrations—many of them page plates—are tolerably faithful, though in some of them scientific accuracy is sacrificed to artistic effect. There is but one point on which we think Mr. Wood must be taken to task, and it is an important one. Mr. Wood, as he honestly enough admits, is a compiler; but there are two ways of compiling, and, in our judgment, he takes the wrong one. One plan is to "boil down" and extract all the material from the works of original writers, without specific acknowledgment; the other is, to quote in each case the authority from whom the facts are borrowed. We regret to say that the first one is that which Mr. Wood has followed, and for which, we think, he must be severely censured.

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* "Bible Animals. Being a Description of every living Creature mentioned in the Scriptures, from the Ape to the Coral." By the Rev. J. G. Wood, M.A., F.Z.S. London: Longmans. 1869.

We can see very well that he has used his scissors judiciously and unsparingly in extracting matter from the writings of Mr. Tristram and Mr. Houghton; but, so far as we have been able to see, he has not given these gentlemen credit for what he has taken from them. This is most reprehensible. Those who know what has been accomplished in the field of Biblical zoology are of course aware that it is these authors, and not Mr. Wood, to whom we are indebted for any exact information on the matter. But the thousands who will read Mr. Wood's volume, and who will read it with pleasure and profit, do not know this; and we are pained to see that Mr. Wood leaves them in a state of ignorance, as much calculated to enhance his own reputation (among this class), as it is to do a lasting injustice to two able and independent original observers.

THE MIDDLESEX FLORA.*

LOCAL Floras are undoubtedly useful, but we fear that the purpose they serve is far from bearing a great proportion to the labour expended in their compilation. For this reason it seems to us to be regretted that botanists like Dr. Trimen should devote their energies to this kind of work, seeing what a vast and productive field lies before them in physiological and fossil botany. It is, however, with the book, and not with the author, that we have to do, and we are bound to admit that *The Flora of Middlesex* is one of the most complete, elaborate, and well digested lists of the plants of a single county ever published. Dr. Trimen and Mr. Dyer have evidently regarded the preparation of this work as a labour of love, and they have made it a most perfect thing of its kind. Indeed, there is no aspect, direct or collateral, of the subject which they have left unnoticed, and so far as Phanerogamia and the ferns are concerned, nothing could be better than this volume. Geology, topography, distribution, climatology, extinction of species, bibliography, synonyms, and even the archæology of Middlesex plants—if we may use such an expression, to designate the study of old treatises and MSS.—have been considered by the authors. The introduction deals with such general features of the county of Middlesex as the following: position, size, shape, boundaries, elevation of surface, geology, drainage, soil, woods, health, rainfall, temperature; and lastly, with the plan of division adopted in the *Flora*. The county of Middlesex has been divided by the authors into seven districts, and the principle followed has been to adhere as much as possible to the natural drainage by the various streams, and hence the divisions are irregular in form. But this irregularity is, as the authors point out, unimportant compared with the advantage derived from a purely natural system, which is divided into districts by the existence of water-sheds, and which has been adopted in that excellent and philosophic work, Mr. Watson's *Cybele Britannica*. The sections adopted

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* "Flora of Middlesex." A Topographical and Historical Account of the Plants found in the County, &c. By Henry Trimen, M.B. (Lond.), F.L.S., and W. T. Thistleton Dyer, B.A. London: Hardwicke. 1869.

then are the following in accordance with the river-basins: 1. Upper Colne; 2. Lower Colne; 3. Cran; 4. Upper Brent; 5. Lower Brent; 6. Lea; 7. Metropolitan. The authors, to give perfect uniformity to their scheme, even put down the last-named district as "drained by the Fleet, Westbourne, Wall brook," &c., but we fear that even this will hardly convey a satisfactory idea as to the metropolitan district being a river-basin or series of river-basins. The plan of the *Flora* is simple. The orders are given as in Babington's *Manual*, the genus following as a sort of heading; the species then follows in black-faced type, and when it has a genuine vernacular name this is given also. Then comes the synonymy, and lastly references to the page in Watson's *Cybele*, and in Syme's *English Botany*, where the plant's distribution is stated, and where it is figured. In the last paragraph it is mentioned whether the plant is very common, common, rather common, rather rare, rare, or very rare. The lists of Cryptogamia, with the exception of the ferns, are very meagre, but the authors did not purpose to deal with them at all, and have merely given them in form of an appendix. The map, which is a geological one, on which the districts are distinctly indicated, is of good size. The index is full, and the list of corrections, we are glad and sorry to say, is somewhat extensive. Altogether the *Flora* deserves the highest praise, and we hope it may reward its authors for the many months of work it has given them.

CHEMICAL ARITHMETIC.*

STUDENTS in chemistry who go up for examination to the London University are too often painfully aware that many of the questions involve arithmetical calculations. Singularly enough, however, exercise in such calculations are generally omitted from our best books on chemistry. It has been Mr. Woodward's aim to meet this want, and we think he has been successful. He has issued his exercises in a series of printed cards enclosed in a sort of map-case. We question the wisdom of this, as the tables now run the chance of being torn or lost, which they would not do if in book form. On the other hand, it must be admitted that in the present form they are very handy and portable for the student. The exercises are ten in number, and relate to the following subjects, the importance of which will be at once seen by the industrious student:—The metric system; thermometer scales and pressure of gases; specific gravity; percentage composition of a body deduced from its formula; empirical formula deduced from percentage composition; quantity of material required to yield a given weight for substance; estimation of volume in certain decompositions; combination and decomposition of gases or bodies in gaseous form; the crith and its uses, and thermal units; and lastly, specific, atomic and latent heat. We do not hesitate to say that every student of chemistry, whether purely scientific or medical, should purchase these tables, and

* "Arithmetical Exercises for Chemical Students." By C. J. Woodward, B. Sc. London: Simpkin and Marshall. 1869.

what is more, work them out thoroughly. The result will be, that "Burlington House" will have less painful associations in their reminiscences of examination periods.

BOOKS ON INSECTS.*

DR. PACKARD has all but completed his fine treatise on insects generally. We have received the last two parts (VI. and VII.), and can only speak of them as we have spoken of those which preceded them—in the most complimentary terms. As a general treatise on Entomology, it is certainly the most comprehensive yet issued. For, valuable and original as Kirby and Spence's well known work is, it is somewhat unsystematic, is to a large extent anecdotal, and of course is immensely behind the present knowledge of the anatomy and development of the class Insecta. In the two parts on our table the author continues his account of the Lepidoptera, begins and completes that of the Diptera, and gets through a good deal of the history of the Coleoptera. Numerous figures are scattered through the text, and Part VI. contains a very good steel-engraved page plate, delineating certain moths. The anatomy of the Diptera is very fully stated, and the author objects distinctly to the idea that the mosquito is provided with glands for the production of any poisonous fluid.

Mr. Scudder's memoir is another American work, and is of the very highest scientific order. It is not long, but it treats minutely on all the burrowing crickets, with the exception of *Cylindrodes* and the minuter forms. It is further interesting from being the first part of the Transactions which the Peabody Academy will in future publish. Mr. Scudder is too well known to European entomologists to need any praise of ours. We can only say, then, that those who know how searchingly patiently he conducts his researches, will find in the present work only another instance of what scientific insect study ought to be. The large 4to. plate which accompanies the memoir is a good example of steel engraving, the central figure of *Gryllotalpa Australis* being a little *chef d'œuvre* of zoological drawing. The other figures strike us as wanting in force, even though they are outlinear. Mr. Scudder describes in detail fifteen species of *Gryllotalpa* and eight species of *Scapteriscus*. The characters of the two genera are strikingly indicated by being placed side by side in parallel columns.

Dr. Knagg's little volume is interleaved with plain paper for the insertion of the reader's notes, and it is a *multum in parvo* of entomological "hints and suggestions." It is not a work on the zoology of Lepidoptera, but it contains over a hundred pages of facts to be noted by those who study the order of butterflies. The author classifies his observation in accordance

* "A Guide to the Study of Insects." By A. S. Packard, Jun., M.D. Parts VI. and VII. Salem. 1869.

"Memoirs of the Peabody Academy. Revision of the Large Stytated Fossorial Crickets." By Samuel H. Scudder. Salem. 1869.

"The Lepidopterist's Guide." By H. Guard Knaggs, M.D., F.R.S. London: Van Voorst. 1869.

with the stages of insect development, and thus we have four different sections in the work, corresponding respectively to the egg, larva, chrysalis, and imago. Under these heads there is nothing left untold which could be said; and as Dr. Knaggs is not a compiler, but simply an entomologist who writes his experiences, everything he says is worthy of attention. In this little volume the butterfly hunter will find all his difficulties smoothed over; and if he wishes to know how, where, when to observe, capture, rear, hatch, preserve, and feed insects, he can have no better guide than Dr. Knaggs.

IRON BRIDGES.*

THE feature which characterises the architecture of the present age is the extensive employment of iron in nearly all structures. It has completely taken the place of timber, and with the best results, and in many cases is used as a substitute for stone and brick. But the use of iron has involved the necessity for skilled calculation of its strength, its power to resist strains, its elasticity, and so forth, such as the older architects never dreamed of. It is of the utmost moment that these points should be thoroughly understood, and it is satisfactory to find that so excellent an authority as Mr. Unwin has published a clear and tolerably simple book for the use of mechanical engineers who have to deal with iron structures. It is one of the characters of this work that it explains the graphic method—now so general in other branches of science—for the determination of data for estimating the pressure and oscillation of iron structures, such as bridges.

SCIENTIFIC AGRICULTURE.†

THE first volume of this work, published a couple of years ago, was chiefly if not wholly written by the principal of the Cirencester Agricultural College. The present volume comprises a series of essays, some scientific and some politico-economical, and by various writers. Among the more important chapters are those on experiments on wheat, grass, and barley, by Professor Wrightson, on the absorptive powers of soils by Mr. R. Warington, and on the distribution of tribasic phosphate of lime, by Professor Thistleton Dyer.

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* "Wrought-iron Bridges and Roofs. Lectures delivered at the Royal Engineer Establishment, Chatham." By W. Cawthorne Unwin, B. Sc. London: Spon, 1869.

† "Practice with Science," vol. ii. Longmans. 1869.

ASTRONOMICAL TABLES.*

GENERAL SHORTREDE'S tables enable the seaman to find the azimuth at sea by means of the hour angle, in all navigable latitudes at every two degrees of declination between the limits of the zodiac, whenever any of the heavenly bodies is observed at a convenient distance from the zenith. Navigators will find these tables economise time materially. Astronomers will also, we think, find them useful.

The author of "How to Keep the Clock Right" shows us the disadvantages of the sextant method and the expense of good transit instruments, and lastly the errors of the "meridian lines," "dipleidoscopes," &c., due to the sun's action on the pillars, &c., to which they are attached. He then describes his own method by observations of the fixed stars, and gives an account of a pillar which is not likely to be affected by the sun. Amateur astronomers will be interested in trying the experiment.

THE FERTILIZATION OF ORCHIDS.†

THIS is a reprint of a most important paper published by Mr. Darwin in the *Annals of Natural History* for last month (September). The paper is a translation of a series of notes prepared by Mr. Darwin for a French edition of his work on the *Fertilization of Orchids.* It contains, on the one hand, corrections of some serious errors into which the author had fallen, and, on the other hand, confirmations of many of his statements. It also contains new facts of interest from the author's observations, and those of other observers. We have not space to abstract the paper, having only received it a few days before "going to press," but we heartily commend it to the attention of all philosophic botanists.

Natural History Transactions of Northumberland and Durham. Part I. Vol. III. Here is a thick honest-looking 8vo. volume, in close type, and with first-class plates. It indicates part of a year's work done up in the North, and it is, like all its predecessors, full of able memoirs, which take equal rank with those of the Linnean and other societies. The Rev. R. F. Wheeler contributes the opening and the final papers, the one being a long report of the meteorology of 1867, and the other a similar record for 1868. The three most valuable articles are those (two) by Messrs. Hancock and

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* "Azimuth and Hour Angle for Latitude and Declination." By Major-General Shortrede, F.R.A.S. London: Strahan, 1869.

"How to Keep the Clock Right by observations of the Fixed Stars with a small fixed Telescope." By T. Warner. Williams and Norgate: 1869.

† "Notes on the Fertilization of Orchids." By Charles Darwin, M.A., F.R.S. Reprinted from the "Annals of Natural History," September, 1869.

Atthey, on various species of Ctenodus, and also on the remains of reptiles and fishes from the shales of the Northumberland coal field, and a paper by Mr. G. S. Brady, on the Crustacean fauna of the salt marshes of Northumberland and Durham. These are all lengthy memoirs, of great value as contributions to science.

Geological Fragments. By John Bolton. London: Whittaker. 1869. A not uninteresting sketch of rambles among the rocks of Furness and Cartmel, displaying careful observation of local geology devoid of any feature of originality, and containing a few very rough sketches of Actinocrinis. It is a sort of book never much read, and out of which publishers seldom realise fortunes.

The True Theory of the Earth. By Research. Edinburgh: Bell and Bradfute. This work reminds us of a class whose authors delight so in quoting Scripture that we at once call to mind that elderly lady who received so much consolation from the constant repetition of the word Mesopotamia. It is a book utterly beyond our province. We can't understand it, and if we did we couldn't review it in these pages.

A new Instantaneous wet Collodion Process. By Thomas Sutton, B.A. London: Green, 1869. The author, who was formerly lecturer at King's College, describes a new process deserving the attention of photographers. The principle on which it depends consists in banishing free acid altogether from the process. The collodion used is neutral, the nitrate bath is neutral, and the sensitive film and the development are alkaline.

Abolition of Patents. Longmans, 1869. This is a reprint of the principal speeches made during the past six months on this subject.

Facts concerning the Sun is a reprint from the *Riverside Magazine* (American) for August. Its illustrations are somewhat sensational, and relate to the August eclipse seen in America.

SCIENTIFIC SUMMARY.

ASTRONOMY.

THE Eclipse of August 7.—The successful observation of this great total eclipse by the American astronomers is undoubtedly the most important astronomical event of the past quarter. The study of solar physics has recently made such rapid progress, and facts of such importance have come to light, that greater attention is attracted towards eclipse-observations than at any former epoch. The circumstances of the recent eclipse were of the most favourable character. The moon's shadow traversed the United States along a course which brought the line of central eclipse close by many of the most important observatories. Then the weather was all that could be desired, so that not one of the observing parties, so far as is yet known, lost any part of the totality. Again, the peculiarities on which the darkness during totality depends were all, it would seem, in favour of the observers. Few circumstances are more perplexing than the different degrees of darkness observed during total eclipses of the sun. In India, during the great eclipse of last year, though the sun was hidden for nearly seven minutes, the darkness was by no means striking; whereas in America this year, although the totality lasted scarcely four minutes, the obscuration was very remarkable indeed. The discovery by Professor Winlock that the spectrum of a prominence which was visible during the eclipse contained no less than eleven bright lines, is perhaps the most interesting result of the eclipse observations. It shows that whatever the prominences may be, they are not simple hydrogen flames. It is to be hoped that our spectroscopists may be able to detect these lines, and so to learn what substances are present in the vast tongues of flame which spring from the solar photosphere.

Search for Intra-Mercurial Planets.—The observers of the eclipse of August 7 searched in the sun's neighbourhood for the planet Vulcan which Lescarbault is supposed to have discovered. If such a planet as this really exist in the sun's neighbourhood, it should be a very conspicuous object during a total eclipse (unless, of course, it happened to be in or near either of its conjunctions). The extreme brilliancy of its illumination would more than make up for its great distance, even assuming it to be in that part of its orbit where it would be further from us than Mercury or Venus at their elongations. No sign of Vulcan or of any of its supposed fellow-planets was detected during the recent eclipse, however; and thus for the present the theory that there are planets within the orbit of Mercury remains in abeyance.

Heat from the Moon.—Few questions have been discussed more closely than that of the heat we derive from the moon. As the moon sends us much light, it seemed likely that she sends us also much heat. But the major part of the heat sent towards the earth being what is called obscure heat, it remained doubtful whether our atmosphere may not wholly or all but wholly intercept the lunar heat-rays. All the experiments made by De Saussure, Melloni, and others, seemed to suggest this view. Recently, however, the powers of the Rosse telescope have been applied to the search for lunar heat. The moon's heat-rays were collected on the face of a delicate thermopile, and the indications of the instrument pointed conclusively to the presence of heat. The experiment was so carefully conducted that no further doubt can exist as to the fact that we receive a certain supply of heat from the moon. Lord Rosse compared the heat thus received with heat derived from certain terrestrial sources; and he came to the conclusion that the heat of the moon's surface cannot be much less than 500° Fahrenheit. When we remember that the surface of the moon is exposed for fourteen days in succession to the sun's action, and that there is no atmosphere to partially ward off the solar rays, we can understand that intense heat should prevail on the moon's surface; and Sir J. Herschel long since pointed out that we cannot ascribe to the moon's surface at the time of full moon a less heat than that of boiling water.

Dr. Tyndall's Theory of Comets.—Dr. Tyndall has given a full account of his views respecting comets. He supposes the atmosphere of a comet to extend to an enormous distance on every side of the head, and that the interception of the solar heat-rays by the head leads to the prevalence of the actinic rays in the part screened by the head. Thus there results the formation of the same sort of cloud—an actinic cloud, he calls it—which is formed in Dr. Tyndall's well-known experiments. As the formation of this cloud-tail is not instantaneous, but may proceed with any degree of velocity (according to the structure of the cometic atmosphere), and as the destruction of the old cloud-tails when they come into the presence of the solar heat-rays, may also proceed with any degree of velocity, the curved appearance of comets' tails is satisfactorily accounted for. Dr. Tyndall's theory is not without difficulties, however; and, as Mr. Huggins has remarked of Benedict Prevôt's somewhat similar theory, it is "obviously inconsistent with the observed appearances and forms of the tails, and especially with the rays which are frequently projected in a direction different from that of the tail, with the absence of tail immediately behind the head, and with the different degrees of brightness of the sides of the tail."

Photographs of the Approaching Transit of Venus.—We have already mentioned that De la Rue advocates the application of photography to the transits of 1874 and 1882. Major Tennant has made several important suggestions as to this mode of utilising the transit. It would obviously be an immense advantage if the difficulties of ordinary observation of Venus in transit could be got over by photographic skill. It may be found that we are to look to photography for the best determination of the fundamental element of astronomy—the sun's distance. Many points of difficulty seem to be mastered in theory by the application of photography. We know that Halley's method of utilising a transit substitutes a time-measurement of t

chord traversed by Venus for the determination—not of the real length of that chord—but of the greatest approach of Venus to the sun's centre. And the reason for the change is obvious. If an observer were sent out to determine how near Venus approached the sun's centre, as seen from a northern or southern station, he would be subject to a number of difficulties. In fact, a very slight consideration of the subject shows that the micrometrical determination of the distance would be practically valueless. But the photographer can at once secure a picture of the sun with Venus on his disc at the moment of estimated nearest approach, besides several photographs taken (at short intervals) before and after that moment, and the examination of these photographs afterwards by an astronomer in his study, with the simple appliances of dividers and protractors, will tell everything that could be learned from trustworthy micrometrical measurements, were such measurements possible.

There are, however, it must be admitted, difficulties of some importance in the application of this method. The optical considerations involved are of themselves sufficient to render the interpretation of the photographs a matter of considerable complexity. And then, again, the distortion resulting from the shrinkage of the collodion film may be much more considerable under the special circumstances of such photographic work as we are considering than under any of the ordinary processes.

As Major Tennant remarks, the probable value of photographic records of the transit is very great, but evidence has still to be adduced on the subject before the method can be unreservedly trusted.

It may be remarked that if it is intended to apply photography to the approaching transit, the places best suited for the purpose would be different from those available for either Halley's method or Delisle's. We know that for the former method places must be chosen where the whole transit is visible, and where, subject to this condition, the displacement of Venus's chord of transit may be greatest either northwards or southwards.. For the photographic method, the latter point alone need be attended to, and the complication, arising from the necessity of considering the earth's rotation, is for the most part got rid of. Delisle's method really involves the determination of Venus's displacement at right angles to the sun's limb at ingress or egress, this displacement being due to the separation of the observers who observe either (i) accelerated and retarded ingress, or (ii) accelerated and retarded egress. Now nothing would be gained by placing photographic stations near those regions suitable for the application of Delisle's method, because the very object of Delisle's method is the securing of non-simultaneous observations, while the perfection of the photographic method consists in the comparison of simultaneous observations made in opposite parts of the earth's surface.

Mr. Hind's Elements of the Transit of Venus in 1874.—Some surprise was occasioned by the circumstance that M. Puiseux had deduced different results than Mr. Hind from Leverrier's tables of the sun and Venus. Mr. Hind, having little faith in the efficacy of a re-examination of his own calculations by himself, placed the matter in the hands of Mr. Plummer, the assistant at Mr. Bishop's observatory, a very able and acute computer. The results of Mr. Plummer's calculations accord so closely with those already

published by Mr. Hind as to leave no doubt that M. Puiseux has fallen into some error in the course of his calculations. Mr. Hind's elements for external and internal contact at ingress differ only 14 s. and 27 s. respectively from Mr. Plummer's values; while the elements for external and internal contact at egress differ only 3 s. and 1 s. respectively. As Mr. Hind remarks, "these differences for such a phenomenon are insignificant; the possible errors of any predictions of the times of contact must be very much larger." The result is fortunate for those astronomers who had taken Mr. Hind's elements as the foundation for inquiries into the circumstances of the approaching transits; though very little doubt was felt that the difference between Mr. Hind and M. Puiseux would be settled as it has been.

Maps of the Transit of Venus in 1874.—Mr. Proctor's maps of the transit are published in the recently issued number of the monthly notices. He claims for them that they indicate in a trustworthy manner all the circumstances of the coming transit. "They were constructed," he remarks, "with every precaution to insure accuracy. The intersection of longitude-lines and latitude parallels to every 10° were separately constructed for by a double process, and in all critical cases further tests were applied. In all, the construction of the maps involved upwards of 3,000 measurements." Mr. Proctor may congratulate himself that he had selected Mr. Hind's elements of the transit on which to base his constructions in preference to M. Puiseux's; for had he selected the latter the greater part of his work would have been thrown away, so far as that rigid accuracy at which he aimed was in question.

Browning's Star Spectroscope.—Mr. Browning has devised a very simple, efficient, and economical spectroscope for astronomical work. It is better adapted for use with telescopes of moderate aperture than any other contrivance hitherto proposed. It will enable the observer to compare the lines in the stellar spectra with the spectra of gases and metals. One of the principal features of the spectroscope is its extraordinary lightness. It weighs only about seven ounces, or less by far than an ordinary micrometer, so that the balance of a telescope will scarcely be at all affected by the addition of the spectroscope.

The November Meteors.—There is considerable doubt as to the nature of the display of November shooting-stars to be looked for this year. Last year, contrary to the expectation of astronomers, the shower was well seen in England. It was seen also in the United States and at Cape Town. Therefore, it is perfectly clear that the portion of the meteoric system passed through by the earth last year was very much wider than the parts traversed in 1866 and 1867. It seems likely that the part traversed this year will be even wider, and therefore if the weather is fine we can scarcely fail to have a shower. Whether, however, the shower will be a very brilliant one is much more open to question. The probability is that it will not be, as all former experience points to the conclusion that the real maximum of condensation was passed by the earth in 1866. However, it is certain that there is great irregularity in the structure of the meteor-system, and therefore it is not at all impossible that during the morning of November 14 next there may occur at intervals several well-masked showers, each lasting

but a short time. It will be useless to watch much before midnight (of November 13-14).

The Sun Spots.—The sun's surface has continued to be much disturbed during the past three months. It is as yet uncertain whether the maximum of disturbance has been attained. Several of the spots which have recently appeared have been of surprising dimensions, and it seems likely that for several months to come the telescopist will find the sun a most interesting object for observation.

The Planets.—Jupiter is the only planet which will be well placed for observation during the next quarter.

BOTANY.

A newly-introduced Fern has been described by Dr. Maxwell T. Masters in the *Gardeners' Chronicle* (Sept. 11), under the name of *Davallia Mooreana.* Dr. Masters describes it as being a very beautiful plant, and the figure he gives is that of a frond of extreme delicacy. The plant is a native of Borneo, whence it was introduced by Mr. Lobb to the collection of Messrs. Veitch and Sons, by whom it has been exhibited during the past season, and who have received for it the award of a First-class Certificate. Dr. Masters states that he has specimens of what appears to be the same fern gathered in the New Hebrides by McGillivray. The rhizome, which is as stout as one's little finger, is of a less rapidly elongating habit than in many other Davallias, and appears to prefer to grow half embedded in the soil; it is clothed with narrow lanceolate dark-brown scales, which are somewhat toothed at the margin. The stipes is about the thickness of a stout straw, from a foot to a foot and a half long, quite smooth and pale-coloured, as are also the somewhat slender rachides. The fronds, independently of the stipites, are from 2 to 3 feet long, and from 1 to 2 feet wide at the base, triangular and pointed, of a graceful arching habit of growth, and most elegantly cut into a multitude of small blunt oblique soriferous segments. Their colour is a pale green, and they are very remarkable for the dotted appearance presented by the upper surface from the prominence of the sori. The obliquely ovate pinnules (secondary) are about an inch long or rather more, the pinnulets (tertiary pinnules) from a quarter to half an inch long. The sori have the elongate cup-shaped form of those of the true Davallias, but, apparently on account of the bulging in the upper surface, the indusium is almost flat. It should be added that the plant is quite different from the D. Moorei of Hooker.

Distribution of the Table Mountain Pine (*Pinus pungens*) *in America.*—So much discrepancy of opinion exists in regard to the distribution of this plant that Mr. J. T. Rothrock gives a note embodying his own experience on the subject in the *American Naturalist* for August. Michaux anticipated that it would be the first of American trees to become extinct, because its limits were so narrow and its habitat so easy of access, and so frequently swept over by fire. Nuttall states "its range is so wide that we have no reason to fear its extirpation." Chapman finds it on the "mountains, rarely west of

the Blue Ridge, Georgia to North Carolina, and northward." In 1859 Gray limited it to "Blue Ridge, Virginia, west of Charlottesville, and southward." In 1863, he adds, on the authority of Prof. Porter, "the mountains of Pennsylvania, &c." In 1867 the same author gives a new locality near Reading, Pa., which was discovered by Thomas Meehan. Unless the above statement of Prof. Porter be taken in a pretty wide light, we have in none of these limits assigned anything like an indication as to how common the tree is in Pennsylvania. Thus far, says Mr. Rothrock, "I have found it ranging from the banks of the Juniata River, in Mission County, Pa., to Penn's Valley, in Centre County, Pa. In the latter place it is extremely common, and often forms the largest portion of the woods. The trees, too, attain a height of fifty and, perhaps I may add, not seldom sixty feet."

Variation in Sarracenia.—An American botanist has observed some interesting varieties of colour in this plant. The deep purple in some of these specimens was entirely absent, the scape sepals and stigma were of a light apple green, and the petals were of a pale yellow.

Examiner in Botany at Cambridge.—We have much pleasure in stating that during the past quarter the examinership in botany for the Natural Science Tripos has been given to Dr. J. D. Hooker, F.R.S.

The Royal Botanic Society of London.—Some time since this Society was alleged by one of our contemporaries to have more regard for funds than for science. Its annual report recently published is evidently a *pièce justificative.* It states that during the season free orders of admission to the gardens for study have been granted to 200 students and artists, and 10,653 specimens of plants have been given to professors and lecturers at the principal hospitals, schools of art and medicine. The maintenance of the portion of the garden devoted to educational purposes is, of course, a considerable item in the Society's expenditure, and for which it receives no return except such as is common to all public benefactors. The collection of living economic plants now contains specimens of all the spices and condiments in domestic use, most of the tropical esculent fruits, many of those from which furniture and other woods are obtained, the principal gums and medicinal products, and the poison trees of Brazil and Madagascar.

Three new Species of Boswellia were described by Dr. Birdwood at the late meeting of the British Association at Exeter, or rather the secretary gave a slight sketch of them, for by some mishap the author's paper was not in the secretary's hands. The three species had been discovered near Arabia, and cuttings had been sent to Bombay, and were thriving plants, although as yet without flowers.

Oats as Protein-yielding Plants.—Herr Dr. Kreusler has a paper on this subject in the *Journal für praktische Chemie* (No. 9). He found that the protein compound was extracted from the coarse oatmeal by means of alcohol of ordinary strength—80 per cent. He states the composition of the pure substance to be in 100 parts—C. 52·59, H. 7·65, N. 17·71, S.1·66, O. 20·39.

The Nutrition of Plants.—In a paper lately laid before the Society of Sciences of Göttingen Herr W. Wicke communicated some results of researches upon the nutrition of plants. He had been experimenting on plants with phosphate of ammonia, hippuric acid, glycine, and creatine. He con-

cludes, from numerous investigations, that all these substances constitute the nitrogenous food of plants which grow in aqueous solutions. As to the changes which they may undergo in the soil, he thinks that a new series of researches must be made to determine this.

The Botanical Appointments in the British Museum.—The *Gardeners' Chronicle* makes the following remarks on this point, and we concur in them thoroughly:—Some time since, when an appointment was made in the Botanical Department of the British Museum, we were not a little surprised, not to say disgusted, to find that one of the conditions imposed upon the candidate for the office was that he should be subjected to an examination by the Civil Service Commissioners. If this examination had had reference to botanical subjects or museum duties there would have been no reason for surprise; but to subject a well-educated gentleman, a graduate of the University of London, whose examinations are known to be the most searching of all similar ordeals, to a test such as is properly enough imposed on unknown men, or on those whose qualifications have not been tested, was to degrade the candidate and to offer an insult to the University. We are glad to find that Mr. James Britten, who has recently been appointed to an office in the Royal Herbarium at Kew, has not had to undergo such a degradation.

Gases exhaled by Fruit.—At a meeting of the Academy of Sciences (Paris) on August 6, MM. Bellamy and Lechartier read a paper in which they stated that various kinds of fruit, after having been plucked from the trees—for instance, apples, cherries, gooseberries, and currants—begin to absorb oxygen and give off carbonic acid.

How Light affects the Decomposition of Carbonic Acid by Plants.—In the *Comptes-Rendus* of August 9, a paper is published by M. Prillieux detailing the results of experiments made on plants with gaslight, electric light, and magnesium light. The experiments were conducted on aquatic plants; the stem of the plant being cut across, and thus allowing the escape of bubbles of oxygen to the surface, these could then be readily counted. He found that whilst in a given time sunlight caused the disengagement of twenty-two bubbles, in the same time under the influence of electric light only eleven bubbles were disengaged. Other lights furnished less. But still, as all the lights caused the disengagement of oxygen, it shows—the author thought—that these sources of light contain the same elements as sunlight.

Alkalies in the Ash of Plants.—M. Cloez calls attention to the fact, already pointed out by others, that the same plants grown near the sea and at remote distances therefrom alter their saline constituents, so that while growing near the sea soda prevails, as a rule, over potassa, the reverse is the case while the same plant vegetates at a distance more or less remote from the sea; of this fact some instances are given in this paper. The relation of the soda to the potassa of the ash of *Crambe maritima* when grown near the sea was as 960 to 1,000; when grown at Paris, as 89 to 1,000. The relation of soda to potassa in the ash of black mustard-seed grown near the sea was as 200 to 1,000, while when grown at Paris it was as 96 to 1,000. Vide *Bulletin mensuel de la Société chimique de Paris*, July.

Artificial Selection in improving Corn.—One of the most wonderful

instances of the application of the selection of varieties to agriculture came before the British Association at Exeter. Mr. Hallett of Brighton succeeded by this method in obtaining a grain of wheat which, when sown, produced a whole multitude of stalks, each of which bore a magnificent ear, well filled with grain. He finds that this quality is maintained by the descendant seeds, and hence he has succeeded in increasing our produce many hundred-fold at least. He laid down the following propositions as the result of his observations: "1. Every fully-developed plant, whether of wheat, oats, or barley, presents an ear superior in productive power to any of the rest on that plant. 2. Every such plant contains one grain which, upon trial, proves more productive than any other. 3. The best grain in a given plant is found in its best ear. 4. The superior vigour of this grain is transmissible in different degrees to its progeny. 5. By repeated careful 'selection' the superiority is accumulated. 6. The improvement which is first raised gradually, after a long series of years is diminished in amount, and eventually so far arrested that, practically speaking, a limit to improvement in the desired quality is reached. 7. By still continuing to select, the improvement is maintained, and practically a fixed type is the result."

The Relative Value of the Characters of Plants employed in classification.—Dr. Maxwell T. Masters had a paper on this important question in the Biological Section at Exeter. The paper was devoted to the consideration of some of the means employed by botanists in elaborating the "natural" systems of classification, and to the estimation of the relative value to be attached to these means. The characters treated of were the following: 1. Characters derived from the relative frequency of occurrence of a particular form, or a particular arrangement of organs. 2. Developmental characters, whether "congenital" or "acquired." 3. Teratological characters. 4. Rudimentary characters. 5. Special physiological characters. 6. Characters dependent on geographical distribution. Illustrations were given in explanation of these matters, and for the purpose of showing their applicability to particular cases.

The Leaf Beds of Hampshire.—The report of the committee appointed to investigate the leaf-beds of the Lower Bagshot Series of the Hampshire basin was presented to the British Association at Exeter, and will appear in the annual volume. The report was made by Mr. W. S. Mitchell, who stated during the past year attention had been drawn to another collection of plants from Alum Bay. It confirmed the view that the forms so abundant on the mainland were wanting here. *Aralias, Dryandras, Cussonias, Dalbergias*, &c., had turned up in great abundance, as well as Cinnamon plants. Mr. Mitchell stated that he had carefully compared these with the cinnamons in the herbarium of the British Museum and at Kew, and, although at first they seemed to have points in common with some other plants, he was fully convinced they were true cinnamons. He pointed out the disadvantage of having but few leaves in an herbarium for comparison, and said the determination could not be considered final with regard to any of the leaves until the figures of them had been accepted by our colonial botanists, in comparison with living plants. Some attention had been paid to Whitecliff Bay, which gives promise of a richer harvest, if a longer time can be devoted to that locality, so as to get into the cliff beyond the

effect of atmospheric action. All the specimens hitherto obtained are very fragile. At Mr. Pilke's pits, near Corfe, the line of fault has lately been worked, and specimens obtained. The effect of the disturbance extends but a short way into the Bagshot Sands. The hope was expressed that the relative horizons of the Alum Bay and the mainland beds would soon be determined by a survey now being made under the direction of the Committee.

The Botany of Thibet.—At a meeting of the Botanical Society of Edinburgh, held on July 8, a paper was read by Dr. J. L. Stewart, conservator of Forests Punjaub, entitled, "Notes of a Botanical Tour in Ladak or Western Thibet." The author gave a detailed account of a tour he made in the autumn of last year through a considerable portion of Ladak, and enumerated the plants he met with, and the elevations at which they grew. From August 5, when he crossed the Baralucha from Lahoul, to October 8, when he crossed the Parang into British territory again, were fifty-one days, on which there was no complete halt. In that time 837 miles were travelled, and seventeen passes of more than 14,000 feet were crossed. He collected nearly 400 species of plants, representing the following natural orders: Ranunculaceæ, 17 species; Cruciferæ, 30; Caryophyllaceæ, 14; Leguminosæ, 21; Rosaceæ, 17; Crassulaceæ, 10; Saxifragaceæ, 6; Umbelliferæ, 10; Compositæ, 57; Primulaceæ, 9; Gentianaceæ, 8; Boraginaceæ, 5; Scrophulariaceæ, 11; Labiatæ, 21; Salsolaceæ, 12; Polygonaceæ, 13; Cyperaceæ, 9; Gramineæ, 39.

The Famine Plants of Central India.—During the last terrible famine in Marwar a number of plants, not generally eaten, were employed as food, and of these a list was made out in a paper lately presented to the Botanical Society of Edinburgh by Dr. G. King. The rainfall of the district in question is usually three to four inches, but in 1868 the rain utterly failed, and the deficiency of food and forage was very calamitous, and attended with loss of life. Dr. King in his paper enlarged upon the effects of denudation under native government, and the subsequent dessication, which called for a system of forest conservancy. In the event of the proposed railway being constructed from Delhi to Bombay, great want of fuel will be experienced. The trees suggested for prospective planting during the rainy season are *Acacia Arabica*, *A. leucophlæa*, and *A. Catechu*, *Salvadora Persica*, and *Capparis aphylla*. The chief jungle products used as food during the late famine were—1. The root of *Hymenochæte grossa*, a tall rush, growing on the margins of tanks; it is called Mothee, and is eagerly dug up for human food. 2. The bark of *Acacia leucophlæa*, a common tree in Rajpootana. 3. The seed of *Anchyranthes aspera*, a common herb. 4. The capsules of *Tribulus lanuginosus*, and other common plants. 5. The seed of a grass, probably an Elusine. 6. The seeds of *Sesamum orientale*, the gingelly oil plant, and of various Cucurbitaceous plants. The whole of these products appear to be deficient in nutritious qualities, and were brought into use to supplement the scanty supplies of esculents in the province at a time of great distress.

The Distribution of Tracheal Vessels in Ferns is the subject of a paper by M. Trécul, in the *Comptes-Rendus* (July 26). The author describes the arrangement of these vessels in a vast number of indigenous and exotic ferns.

Significance of "Adnation" in the Coniferæ.—A paper of some importance was read before the American Association for the Advancement of Science by Mr. T. Meehan, and was published in the volume of Transactions. The author shows that the true leaves of coniferæ are adnate with the branches.

The Development of Mucor Mucedo.—In the *Monthly Microscopical Journal* for September there appears a most valuable paper by Dr. R. Maddox, detailing the different stages in the development of this easily accessible fungus. It is accompanied by a plate giving numerous figures sketched by the author, and drawn on stone in Mr. Tuffen West's best style.

Structure of Fossil Exogenous Stems is the title of a recent important communication by Professor Williamson, of Manchester. The author enters on a critical examination of the opinions of Endlicher and Brongniart, and figures and describes the structure of Dadoxylon and Dictyoxylon and other genera. The paper is of some length, and deserves the attention of palæontologists. The author thinks that no determination of fossil plants can be made with accuracy without the aid of the microscope. Vide *Monthly Microscopical Journal*, August.

CHEMISTRY.

The Homologous Carburets of Naphthaline.—This was the title of a paper presented recently to the Society of Sciences of Göttingen by Herr Fittig. Having referred to his former paper showing how, beginning with benzol, all the homologues may be formed in a simple manner therein described, he stated that he obtained good results by the application of this method to the aromatic series. By it alone have he and his colleagues been enabled to obtain the homologues of benzol in a state of purity; except toluol, the carburets previously obtained from tar were but a mixture of carburets in juxtaposition, and very difficult to separate. In the paper read, he detailed how, with M. Remsen, he has been trying this method with naphthaline, and how he has obtained very good results. In this way he has obtained many homologues of naphthaline. The following reactions were then described in detail: (1) A mixture of monobromated naphthaline and iodide of methyl, and (2) a mixture of monobromated naphthaline and iodide of ethyl diluted with ether, upon sodium in a state of fine division. He described two new carburets. He thinks it probable that the homologues of naphthaline are found only in those portions of tar which boil at a high temperature. He thinks, therefore, that the reason why they have been hitherto overlooked is that they are liquid at ordinary temperatures.

What to be looked for in examining Water.—In summing up the results of his observatious (published in a series of long papers in the *Chemical News*) Dr. Angus Smith thus formulates what data are required for sanitary purposes. 1. Quality of the organic matter. 2. Condition of the gases of decomposition. 3. Organic matter: easily-decomposed organic matter, and slow to decompose. 4. Nitrates as remnants of organic matter. 5. Nitrites. 6. Chlorides, with precautions, as indicating animal sources when greater

accuracy is wanted. 7. Oxygen of the dissolved air as indicating the activity of the decomposition. 8. Total organic matter. (This the author found by weighing.) 9. The usual inorganic analysis. The author considered that, for purely sanitary purposes, the Nos. 1, 2, 3, and 6 were the most important. Vide *Chemical News*, September 3.

The Fermentation of Beet-root Sugar.—In the *Comptes-Rendus* of July 12 a memoir has been published by MM. Pierre and Puchot on the results of the fermentation of beet-root sugar. They state that in certain cases they had found besides amylic alcohol—whose presence had been already ascertained—vinic aldehyde and butylic alcohol. Their researches were made on a large scale, for they manufactured no less than 50 litres of amylic alcohol, 13 litres of butylic alcohol, and 7 litres of propylic alcohol. They have also investigated the products of fermentation of apple-juice, but in these they found only propylic alcohol and no amylic alcohol.

The Synthesis of Hydrocanellic Acid.—A very long and valuable paper by Herr Fittig will be found in *L'Institut* of August 18.

Jargonia.—A paper on jargonia was sent to the British Association by Mr. Sorby. It showed that the substances known as zinconia and jargonia are distinct, especially in colour. The colour was thought due to the existence of iron, though subsequent experiments may show the colour is due to some other substances; but, taking all the facts now known into consideration, it seems extremely probable that, after ignition, jargonia is of a clear straw-colour, paler than that of tungstic acid, but deeper than that of ceroso-ceric oxide.

Isomery in the Salicyl series.—M. Louis Henry, in a memoir read before the Royal Academy of Belgium and reported in *Scientific Opinion* (August 11), explained some recent researches in the above subject. He tried, if possible, to determine the chemical relation which exists between the various members of this series. With this view he has produced the bichlorated salicylic cresol, the trichlorated metatoluene, and the metachlorobenzoic, or chlorosalylic, aldehyde. The well-known properties of salicylic aldehyde and its intimate relations with salicylic acid, whose chemical significance is well known, enables the author to view it at once as an aldehyde and a phenol. The following formulæ express these relations:—

$$C^6H^4\begin{cases}HO\\CHO\end{cases}$$

If this interpretation is true, salicylic aldehyde ought, in this double capacity, to be able to develop—by successive or simultaneous replacement of the hydroxyl, HO, or of the aldehydic oxygen, by chlorine in equivalent quantity, under the action of an agent suited to these processes of substitution, such as pentachloride of phosphorus—the three foregoing derivatives. The first two have been obtained by the action of the pentachloride on the aldehyde itself; decomposed by water with heat, the second furnished the third.

The Chemistry of the Air.—In the report just issued by the Inspector under the Alkali Act, the inspector gives the following as a summary of conclusions in reference to the state of the air: "The rain from the sea (Western Islands) contains chiefly common salt, which crystallises clearly.

The sulphates increase inland before large towns are reached. The sulphates rise very high in large towns, because of the amount of sulphur in the coal used, as well as decomposition. When the air has so much acid that two or three grains are found in a gallon of the rain-water, or forty parts in a million, there is no hope for vegetation in a climate such as we have in the northern parts of the country. Free acids are not found with certainty where combustion or manufactures are not the cause. Experiments in the direction indicated above may enable us to study and express in distinct language the character of a climate, and certainly of the influences of cities on the atmosphere."—*Fifth Report* published by Spottiswoode, and presented to both Houses of Parliament.

To prevent Bumping in Boiling.—The *bête noire* of chemists is the phenomenon known as bumping. The following method of preventing bumping has been described by Dr. Hugo Müller in the *Chemical News* (July 30), and deserves trial: "For ordinary purposes I have found it still more convenient to introduce into the liquid about to be distilled a small fragment of sodium amalgam, or, in cases where the liquid is acid, a small piece of sodium-tin. Methylic alcohol is well known to be one of the most difficult liquids to distil, yet on the introduction of a minute piece of sodium amalgam or sodium-tin it can be distilled without the slightest inconvenience. I found on one occasion that more than 400 grammes of methylic alcohol distilled over with perfect steadiness, and without exhausting the activity of a fragment of sodium-tin, weighing not more than 0·060 grms. It is, perhaps, hardly necessary to mention that the action of sodium amalgam and sodium-tin is due to a minute but continuous disengagement of hydrogen taking place during the process of distillation."

Apomorphia is the name of the curious compound obtained by Dr. Matthiessen from morphia, by acting on it with acids at a certain temperature. It has no narcotic properties, but is a most powerful emetic. The discoverer's account is published in the last number of the *Proceedings of the Royal Society.*

Researches on Vanadium.—The second part of Prof. Roscoe's valuable paper (the first part was the Bakerian lecture for 1868) was read at the last sessional meeting of the Royal Society.

The new Chemical Chair in Anderson's University.—A new chair has just been founded by Mr. Young (of parafin oil celebrity, we believe) in this private university. It is a chair of technical chemistry, and has been given by Mr. Young to his friend Mr. W. H. Perkin, the celebrated discoverer of the coal-tar colours and Secretary to the Chemical Society. The chair is worth about 300*l.* a year.

A new Dye from Madder.—Though it is probable that the newly discovered artificial alizarine will do away altogether with the cultivation of madder, it is interesting to learn that a new colour has been obtained from this plant. Prof. Rochleder, at Prague, has found that, when madder is treated with dilute mineral acids, it yields, beside alizarine and purpurine, a small quantity of a third tinctorial substance, which, in alkaline solution, has a great similarity to chrysophanic acid dissolved in alkaline solution; acids precipitate it from this solution in the amorphous flocculent shape, the precipitate being of a pale yellow colour. This substance is soluble in

alcohol and in acetic acid, and crystallises from these solutions, on the evaporation of the solvent, yielding orange-yellow coloured crystals; its aqueous solution mixed with acetic acid, and brought to boiling point, imparts to silk and wool immersed in that bath a beautiful and durable golden-yellow colour.—*Cosmos*, July 3.

Improvement in the Preparation of Carbonic Oxide.—In its most valuable and well-prepared summary of foreign chemical progress, the *Chemical News* gives the following abstract of a paper on this subject: When the gas just alluded to is evolved from a mixture of oxalic and sulphuric acids, as is well known, a mixture of carbonic acid and carbonic oxide gases is obtained. This mixture of gases the author causes to pass through a tube made red-hot in a suitable furnace and filled with charcoal previously well re-burnt; and, after having washed the gas through a solution of potassa, and also lime-water, he thus obtains a bulk of the pure carbonic oxide gas three times larger than would be the case if the carbonic acid simultaneously formed were not decomposed by the red-hot charcoal, which must be free from yielding any carburetted hydrogen gases.

An improved Bunsen's Filter.—Mr. R. S. Dale, in a letter to the *Chemical News*, dated September 8, writes to say that he has made some improvements of use to chemists. In the place of the cone of platinum foil recommended by Bunsen, he now uses a cone made either of platinum or copper gauze. When the fluid which passes through the filter does not act on copper, he prefers the latter. The cones are cut just as Bunsen describes, but can be fitted to the funnel direct, that is, without the use of a matrix of plaster-of-Paris. This is accomplished by pressing the cone into the funnel to be used, with a piece of wood turned as nearly as possible to the proper angle. He adds that during the last three months, in which these cones have been in almost daily use, he found them to filter much quicker than the foil cones, and with quite as little risk of breaking the paper.

GEOLOGY AND PALÆONTOLOGY.

The Fossils of the "Calcaire grossier."—The Royal Academy of Belgium have determined to publish in 4to the fine memoir by MM. Cornet and Briart on this subject.

A Fossil Tubularian.—Dr. P. Martin Duncan has discovered, conjointly with H. M. Jenkins, a new genus of tubularian Hydrozoa from the carboniferous formation. It is called Palæocoryne, and was described in a paper read at one of the late meetings of the Royal Society. *Palæocoryne* is a new genus containing two species, and belongs to a new family of the Tubularidæ. The forms described were discovered in the lower shales of the Ayrshire and Lanarkshire coal-field, and an examination of their structures determined them to belong to the Hydrozoa, and to be parasitic upon Fenestellæ. The genus has some characters in common with Bimeria (St. Wright), and the polypary is hard and ornamented. The discovery of the trophosome, and probably part of the gonosome of a tubularine hydrozoon in the Palæozoic strata brings the order into geological relation with the doubtful Sertu-

larian Graptolites of the Silurian formation, and with the rare medusoids of the Solenhofen stones.

Geological Map of Central Europe.—It is asserted by Cosmos that a very greatly improved and enlarged geological map of Central Europe has been prepared and edited by the well-known geologist, *emeritus* Director-General of Mines for Prussia, Herr von Dechen. This new map is on a scale of 2,500,000ths, and embraces the whole of Germany, France, England, and adjacent countries. The same author has recently finished a large geological map, in 32 sheets, of Rhenish Prussia and Westphalia, which may be considered as one of the best ever executed of the kind, and one of the finest specimens of chromo-lithography ever published. The price of these works being very moderate will insure them a largely-extended sale.

Flint Implements in the Valley of the Thames.—At the Exeter meeting of the British Association, Colonel Lane Fox gave an account of some investigations lately carried out at Acton and at various places along the Thames valley. He had found a large number of flint implements in such a position as to leave no doubt that the river Thames had once occupied banks 100 ft. higher than the present, and for many miles in width.

British Fossil Corals.—The report on these was presented to the British Association by Dr. P. M. Duncan. After describing many new species, and noticing the 140 kinds already described, the author stated that 251 species of corals had been found in British Secondary and Tertiary strata. The presence of certain kinds of corals in strata was shown to indicate peculiar conditions of sea-water. The report concluded with a statement concerning the periods when the area of England was occupied by an ocean with coral reefs, or by moderately deep seas and shallows. The condition of this area was then compared with that of the continent during the Secondary and Tertiary periods, and it was shown that coral reefs fringed the old coast-line.——"Report of Committee on Photographs of Corals."—Mr. J. Thomson, the author of the above paper, has devoted considerable time to cutting very thin sections of fossil corals, and afterwards photographing them. This method has afforded palæontologists a natural means of studying the structure of these interesting fossils. When mounted on glass these sections can be magnified to any extent by the oxy-hydrogen lantern, and thus these old-world forms, which are of great beauty, can be made to illustrate their own history.

Tertiary Fossils in the Neighbourhood of Brussels.—M. P. de Borre has described to the Belgian Academy the results of an examination of a collection recently presented to the National Museum. In this collection the author found the remains of two Chelonians. In his paper he described: 1. A fragment of a sternum, which he thinks belongs to a species of *Emys*. 2. Two incomplete vertebræ, an atlas and an axis, which he believes to have belonged to an *Emys*, and possibly *Emys Camperi*. 3. A bone which seems to be the metatarsal of the median digit of a marine tortoise. 4. Another bone, also a metatarsal, belonging to the second or fourth digit. 5. A bit of the carapace of an *Emys* or a *Chelonia*. 6. A fragment of a dorsal-plate of a tortoise of the family of Potamites.

A new Devonian fish has been discovered and described by M. Van Beneden. He has given it the name of *Palædaphus Devoniensis*, because it is

related to a plagiostome fish, which he and M. de Koninck have styled *P. insignis*.

New Zealand Saurian Remains.—In a paper read before the Philosophical Institute of Canterbury, New Zealand (June 3), Dr. Haast read a paper, in which he gave a sketch of a saurian from the Waipara which differs from any saurian remains hitherto discovered. The specimen belonged to the sub-order Amphicœlia.

Death of two eminent Geologists.—It is with much pain that we have to record the loss during the quarter of two very eminent geologists, Professor Beete Jukes and Mr. W. J. Salter. The latter, we regret to say, committed suicide while in a state of unsound mind. It is said that Mr. Hull will succeed Professor Jukes in the Irish appointment. Mr. Salter had for some time retired from the active pursuit of geology.

How to Determine an Unseen Fault.—In an excellent practical paper in the *Geological Magazine* (August), and which we commend to the young geologist, Mr. H. B. Medlicott makes the following useful remarks: In determining the existence, position, and amount of an unseen fault in stratified rocks, great attention has to be directed to the dips and strike of the strata. I would thus partially account for an error that seems to have gained credit with many field geologists, that the existence of a fault can be detected from a one-sided examination of the dips—from the arrangement of the strata on one side of the supposed fault. The question is a vital one, for it obviously comes most frequently into operation in important cases of apparently great "master-faults," where later sedimentary rocks are in juxtaposition with crystalline, or widely distinct masses. The origin of such a notion is, perhaps, traceable to the "fixed idea" of the fundamental principle of geology—the *super*-position of the younger deposits. However this may be, it would seem to be a rule with many observers at once to set down as a fault any abrupt, steeply inclined, junction of rocks of different ages, and showing signs of disturbance. A reference to any actual area of the earth's surface would, in the first place, remind one that in any basin of deposition new strata must often abut against steep surfaces of the old supporting rock. And upon the second point (that of disturbance), a brief consideration would satisfy one that a subsequent lateral compression, modified by slightly varying conditions of resistance, might produce any imaginable complexity of dips in the younger strata near such contact.

The Fresh-water Deposits of the River Lea.—Mr. H. Woodward read a paper descriptive of these before the British Association. Certain excavations made by the East London Water Works Company had revealed the presence of shell marl on the Walthamstow marshes. The marl was accompanied by vegetable remains, and bog-iron ore. All the shells are recent, and the most notable fact connected with the bed was the presence of bronze spear-heads, arrow-heads, knives, &c. These were accompanied by bones of man, wolf, fox, beaver, wild boar, red-deer, roebuck, fallow-deer, reindeer, &c., as well as of the sea-eagle, and fishes. As late as the year 1700 the entire tract was forest-land. In 1154 the same country is described as abounding in wolves, wild boar, wild bulls, &c. Mr. Woodward thought that the maintenance of a royal forest had been the means of preserving this bed. In the deep cutting of the bed, remains of the Mammoth were met

with. The author thought much of the deposit might fairly be ascribed to the beaver working and making dams, in the old valley of the Lea.

Professor Phillips's Exeter Lecture.—The lecture on Vesuvius which Professor Phillips gave at Exeter was perhaps the best illustration of a popular lecture that could be conceived. It dealt with the modern views of volcanoes, and was illustrated by some apt experiments—one of a working model of a geyser afforded much amusement by shooting out a stream of hot water, which deluged a number of those on the platform—and was given in a vein of humour which kept the audience thoroughly awake throughout.

The Geological Society.—It would be impossible to give abstracts of the numerous papers read at the meeting which took place as our last number went "to press" (June 23). But we may refer to a few of the more important. One of these was a note on a very large Saurian humerus from the Kimmeridge clay of the Dorset Coast, by J. W. Hulke, F.R.S., F.G.S. This stupendous limb bone, 31 in. long, was obtained from Kimmeridge Bay by J. C. Mansel, Esq. It had a subcylindrical shaft, a transversely elongated proximal, and a cubical distal extremity. The distal end is mapped out by a wide shallow posterior groove, and a narrower but deeper anterior notch, into a couple of condyles, of which the inner or posterior is the larger. The anterior border of the shaft towards the proximal end rises, as if to form a deltoid crest. The cortical tissue of the shaft is remarkably dense and polished. There is not any medullary cavity, but the interior of the cortex is filled with cancellous tissue. The author pointed out that the form of the terminal surfaces removed the bone from all the Enaliosaurians, and brought it into close relation to the humerus of existing Crocodilians, from which, however, it differed in its being less curved and by its great size. He next referred to its differences from the humerus of the Dinosaurus, Iguanodon and Hylæosaurus, and remarked that it most nearly resembled the large limb bone on which Mantell founded his genus Pelorosaurus.—Another paper was by the same author, on some fossil remains of a Gavial-like Saurian from Kimmeridge Bay, establishing its identity with Cuvier's *Deuxième Gavial d'Honfleur* and with Queenstedt's Dakosaurus. The fossils which formed the subject of this communication were also collected by Mr. Mansel in Kimmeridge Bay. They demonstrated the existence of a Saurian having long subincurved, subretrocurved, laterally compressed, unequally convex teeth, with an anterior and posterior finely serrated edge, loosely implanted in distinct and separate sockets, and vertically replaced by young teeth rising into the base of the large open pulp-cavity of the fang of the old tooth. The lower jaw, of which the greatest part of the right half is preserved, is about 40 in. long. The symphysis is very long, and includes the opercular bone. The upper jaw shows a terminal undivided nostril, not inflated laterally as in the Teleosaurus. The lines of the jaws seem to merge into the cranium less abruptly than in the living Gavial, which gives the outline of the head a greater resemblance to Mecistops. The vertebræ are biconcave, and the outer surface is hollowed and somewhat overhung by the roundish articular surfaces. The transverse processes are long and directed outwards, and slightly backwards and downwards; their posterior border thick, the anterior thin. The ribs have bifurcated spinal ends. The femur, 14 in.

long, resembles that of the living Crocodilians, only it is less twisted. The structure of the jaw, the form and attachment of the teeth, and the manner of their succession, with the form of the vertebræ and ribs, proved this Kimmeridge Saurian to be a Crocodilian (and not a Lacertilian) resembling a bastard Gavial. The author next demonstrated its identity with *Dakosaurus*, Queenstedt, and hence with *Geosaurus maximus*, Plienger; and he expressed a belief that it was also generically indentical with Cuvier's Honfleur Gavial, "tête à museau plus court," and Geoffrey St. Hilaire's *Steneosaurus rostro-minor*.—The following papers, all of which we cannot abstract for want of space, were also read: "On the Graphite of the Laurentian of Canada," by Professor J. W. Dawson, LL.D., F.R.S., F.G.S. The author described the modes of occurrence of great quantities of graphite in the Laurentian limestones of Canada. He regarded the presence and characters of this mineral as indicative of the existence of plants, side by side with Eozoon, at the period of the deposition of these limestones.—"Notes on certain of the Intrusive Igneous Rocks of the Lake district," by Dr. H. A. Nicholson, F.G.S.—"On the Fossil Myriapods of the Coal-formation of Nova Scotia and England," by Samuel H. Scudder, Esq., communicated by Sir Charles Lyell, Bart., F.R.S., F.G.S.—"Rodentia of the Somerset Caves," by W. Ayshford Sandford, Esq., F.G.S.—"On a new Acrodont Saurian from the Lower Chalk," by James Wood Mason, Esq., F.G.S., of Queen's College, Oxford.—"On the Correlation, Nature, and Origin of the Drifts of North-west Lancashire and part of Cumberland," by D. Mackintosh, Esq., F.G.S.—"On the Connection of the Geological Structure and Physical Features of the South-east of England, with the Consumption Death-rate," by W. Whitaker, Esq., B.A., F.G.S.—"On the Geology of a Portion of Abyssinia," by William T. Blanford, Esq., F.G.S., &c.—This paper contained a brief description of the principal geological observations made by the writer when accompanying the late Abyssinian expedition.—"On the Volcanic Phenomena of Hawaii," by the Rev. C. G. Williamson, communicated by Sir R. I. Murchison, Bart., F.R.S., V.P.G.S.—"On two new Species of Gyrodus," by Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., V.P.G.S.

MECHANICAL SCIENCE.

British Association for the Advancement of Science.—Amongst the papers communicated to the mechanical section, we may mention a further report by Dr. Fairbairn on the strength and other properties of steel, containing the results of a large number of new experiments.—A paper on the application of hydraulic buffers to check the recoil of heavy guns by Col. H. Clerk, R.A. These buffers are close cylinders filled with water attached to the gun platform. In the cylinder is a piston with a piston-rod attached to the gun. During the recoil the piston traverses the cylinder and displaces the water, which passes through four small holes in the piston; and the work expended in forcing the water through these apertures absorbs the force of the recoil. The buffers appear to have been very successful, even with guns of 25 tons weight.—Mr. Whitworth read a further paper on the superiority

of steel flat-fronted projectiles, for penetrating armour, to the chilled cast-iron Palliser shot which have pointed fronts. Mr. Whitworth quoted experiments to show that when a plate was struck obliquely a flat-fronted shot would penetrate, whilst a pointed shot would break up and be deflected. He stated that he was engaged in the construction of some guns of 11 inches calibre, capable of withstanding a powder charge of 90 lbs., and firing an 11-inch shell weighing 965 lbs. and carrying a bursting charge of 45 lbs. of powder.—Mr. Eaton read a paper on what he terms aero-steam engines, or engines which work with a mixture of steam and air. The engine is fitted with an air-compressing pump, by which air is forced through a coiled pipe, exposed to the exhaust steam and waste furnace gases, from which it is delivered into the boiler, and passes with the steam to the engine cylinder. According to experiments at Nottingham, the evaporative efficiency of the boiler and the efficiency of the engine are both increased, and a considerable economy of fuel was obtained. Further and more varied trials will be required to show how far this gain is due to the special circumstances of these particular experiments, and how far the same gain may be realised in ordinary engines of good type under the conditions of common practical working. The invention at its present stage at least promises to be serviceable. —Mr. Bramwell read an interesting paper on the influence of form, considered in relation to the strength of railway axles and other portions of machinery subjected to rapid alternations of strain. The paper is chiefly occupied by an examination of the effect of bosses and other enlargements in modifying the distribution of stress and the work necessary to cause fracture.

Resistance of Vessels.—An extremely important report, drawn up by Mr. Merrifield for the committee of the British Association appointed to enquire into the state of existing knowledge on subjects relating to the resistance and propulsion of vessels, was presented at the Exeter meeting. The report contains a complete account of the formulæ and theories which have been proposed for estimating the resistance of vessels; a short account of the principles of propellers with references to the memoirs which contain information on the subject; an account of the chief experiments on the resistance to the motion of floating bodies; and an account of the theories of waves and of the rolling of ships. The committee suggest a series of experiments on a ship of considerable size and fine form, towed at various speeds, the resistance being measured by a traction dynamometer. They suggest that the experiments should be made in a deep and clear inland water, such as may be found on the coasts of Norway and Scotland.

Fairlie's Steam Carriage.—Mr. Fairlie's steam carriage, or engine and carriage combined, has been working admirably at Hatcham on an experimental line with curves of 50 feet radius. Thirty miles an hour is said to have been accomplished. The engine and carriage weigh but 13½ tons, and there is accommodation for 66 passengers.—*Engineering*, Aug. 20.

House raising.—Many of our readers will know that in the United States the lifting of houses bodily and removing them to more desirable locations has become a regular branch of engineering. The latest feat of the kind is the raising of the Hotel Pelham, in Boston, a freestone building 96 feet high, and weighing 10,000 tons, and its removal on rollers a distance of 21 feet in three days.

Steam Towage on Canals.—In the use of steam-propelled vessels on canals great difficulty has been experienced from the loss of efficiency of either paddle wheels or screws in confined channels. The water, driven back by the propeller, necessarily placed in the stern, must be replaced by water flowing from the front through the narrow passages between the boat and the banks. If such a vessel is used as a tug, there is a disadvantage from the wash of the propeller being thrown on the bows of the vessels in tow. And the waves caused by the propellers seriously injure the banks. Mr. Max Eyth, of Leeds, in a paper read at the Institute of Mechanical Engineers, described a mode of propulsion by which these difficulties are overcome. A wire rope is laid in the bed of the canal from end to end, and anchored at its extremities. This rope is passed over a clip drum in the boat, and by means of an engine the boat is wound along by a direct pull on the rope. This system of clip drum and submerged rope was invented by Baron Oscar de Mesnil and Mr. Max Eyth; the first experiment with it was made at Leeds in 1866, and further trials had been made in Belgium and America. It had been applied on the Meuse from Namur to Liége, a distance of 42 miles, and was being extended to Antwerp. The cost of towing only amounted to one-twentieth of a penny per ton per mile, including working expenses, management, and interest. The cost of towing by animal power is about seven times as great. With paddle tugs on the Thames the cost is nine times as great. The cost by screw tugs on English canals was five times as great. Mr. Hawksley expressed an opinion that, for slow transit and heavy traffic, canals might advantageously compete with railways.

Velocipedes.—Professor Rankine has communicated a series of articles on the theory of velocipedes to the pages of the *Engineer.*

Channel Tunnel.—The best means of improving the communication between England and France has at last begun to receive serious consideration. Visionary projects of tunnels and bridges have been succeeded by carefully matured and well-investigated schemes put forward by competent engineers in such a form that the probabilities of success, in so vast an undertaking, may at least be seriously discussed. Mr. Hawkshaw has made a costly and careful survey and an examination of the strata by borings, which have satisfied him that a tunnel could be carried across the Channel entirely in the lower chalk. This material is one in which tunnelling is easy and rapid, and in which the risk would be limited to one contingency, namely, the possibility that the sea would find its way into the workings through some fissure. Mr. Hawkshaw estimates the cost at ten millions, and the time required for the execution of the tunnel at nine or ten years. He proposes to test the probabilities of success by the construction of preliminary driftways. If these were safely carried across the certainty of success would be assured. If they failed the loss would not exceed two millions.

More recently Mr. Bateman and Mr. Rèvy have suggested a plan for constructing an iron tunnel on the bed of the English Channel. The most interesting point about this scheme is the proposal to put the segments of the tube together in a sort of huge diving bell, attached water tight to the completed part of the tunnel, and pushed forward by hydraulic presses as the work advances. This bell is to be a cylinder 80 feet long, 18 feet diameter, and would weigh in air 750 tons, in water 100 tons. The tunnel

itself is proposed to be 13 feet in internal diameter and 4 inches thick with strengthening rings and flanges. It is estimated that 100 feet of this cast iron tunnel can be laid per day, and that with the exception of the shore ends three and a half years would serve for its completion. Ordinary railway carriages would be worked through the tunnel by pneumatic pressure. The speeds proposed are 20 and 30 miles per hour. The total outlay is estimated at eight millions, and upon this sum it is thought that the goods traffic alone (assumed at 4,000,000 tons per annum) would pay a handsome dividend. All the details of the scheme have been carefully matured.

MEDICAL SCIENCES.

Injection of Liquor Ammoniæ in Snake-bite.—Dr. Fayrer, of Calcutta, has made a very concise experiment to test the value of Dr. Halford's method of injecting liq. ammon. in cases of snake-bite. We ourselves some time ago expressed an *à priori* conviction that the remedy was as bad as the disease. Dr. Fayrer has lately (*Indian Medical Gazette,* July) described one of his experiments on a dog, and he thus sums up his observations:—The object of this experiment was to test the effect of the liquor ammoniæ injected into the venous circulation in an animal uninfluenced by the poison. It was used of the sp. gr. ·959 B. P., as directed by Professor Halford, and it was injected into the femoral vein in the manner suggested by him. The impression produced by this experiment was that the dog had a very narrow escape from death, and that the effects of the ammonia had nearly proved rapidly fatal.

New Tonic.—M. Blanchard, in a recent number of *Comptes-Rendus,* describes at length the characters and properties of a new remedy, allied to cascarilla, to which the name of conden or coni-xan has been given. The cortex of the root is the part employed. Of this an infusion is made, about one ounce being used for each dose.

Death of Professor Purkinje.—During the quarter we have lost one of the best known of continental physiologists familiar to the student in connection with the "axis cylinder of Purkinje," and also with the "germinal vesicle." Professor Purkinje, of Prague, one of the most celebrated physiologists of modern times, and especially known for his researches on vibratile cilia, the structure of nerve fibre, and the development of the ovum, died July 28, in the eighty-second year of his age.

The Relation as to Area between the Tendon and the Muscle.—Professor the Rev. Samuel Haughton has lately published some interesting observations on this subject, and especially in regard to the supposed ratio between the cross section of the muscle and its tendon. He concludes that the cross section of a muscle does not bear a constant ratio to the cross section of its tendon, unless the friction experienced by the muscle and tendon be also constant, and that there may even be a *surplusage* of strength in the tendon beyond what is absolutely necessary to resist the combined force of the muscle and friction. This surplusage, however, cannot be supposed to be large, if the principle of *economy of material* in nature be admitted.

Artificial Mammæ.—That which is wrongly styled civilisation is certainly at its zenith when we require artificial mammæ for our imperfectly developed maidens. Strange, however, as it may appear, a patent has been actually taken out by Mr. J. D. Thomas, of Liverpool, for what he terms an artificial bust, but which we conceive to be nothing less than what we have stated. *Voici* the specification:—The inventor forms the whole of the parts of air-proof or nearly air-proof materials, the back, or that portion worn next to the person, being made of a rigid or stiffish material, such as cardboard, vulcanite, or other hardened india-rubber, and the front or raised portion of a flexible material, such as india-rubber or other so-called air-proof cloth. The inflating is effected preferably in an atmosphere of about 60° Fah., or air or other gas at that temperature is admitted before the parts are permanently closed.

Experiments in Tinea Favosa.—At the meeting of the French Academy on August 16, M. de St. Cyr sent in a memoir detailing his experiments in the extension of this parasitic affection. He made some of his experiments on dogs, and he has since found that all the mice in the same locality are infected. Hence he concludes that the disease may be communicated to man from animals.

Medical Science at the British Association.—The only medical communication of importance at the British Association meeting was that of Dr. B. W. Richardson, in the form of a Report on Anæsthetics. The author dealt with the chemistry of the whole series of complex organic compounds relating to this class of bodies. He showed that they produced only marked effects when introduced subcutaneously, and that administered in this way they were twice as active as given in other ways. He again declared against the supposed advantage of alcohol as a food.

Physical Action of the Atropine.—From a very elaborate series of experiments lately carried out by Dr. F. B. Nunneley, he states that the action of atropine on the heart is neither considerable nor energetic, a progressive weakening of its power being the most prominent visible effect. The heart continues to beat for some time after the manifestations of life in the rest of the animal have disappeared; finally, it slowly dies itself, the ventricle being left in a state of relaxation. This occurs at the end of ten, twelve, or several more hours.

METALLURGY, MINERALOGY, AND MINING.

Analyses of Aspidolite and Paragonite.—In the *Journal für praktische Chemie*, No. 11, Herr von Kobell gives the following as the composition of these two minerals:—Aspidolite in 100 parts; silica, 46·44; alumina, 10·50; magnesia, 26·30; protoxide of iron, 9·0; soda, 4·77; potash, 2·52; water, 1·13. Paragonite—Silica, 48·00; alumina, 38·29; peroxide of iron, 0·91; soda, 6·70; potassa, 1·89; magnesia, 0·36; water, 2·51.

Enstatite in Meteoric Iron.—In a paper read before the Academy of Science of Vienna at a recent meeting, Herr Lang gave some details as to the form of enstatite contained in the meteoric iron of the Breitenbach

meteor, the greater part of which is now in the British Museum. The iron has an evidently porous structure, and the pores inclose a green silicate offering the crystallographic and optic characters of enstatite, and even its chemical composition according to the analysis of Professor Maskeleyne.

The Physics of Tempering and Annealing.—At the meeting of the Academy of Science (Paris), on August 2, M. Richal read a paper on the variations which metals undergo as to density during the processes of tempering and annealing. The density of steel, which is 7·88, descends during tempering to 7·73, and ascends during annealing to 7·83. On being tempered again it descends to 7·73, and these phenomena may be repeated at will. On the other hand, the density of bronze is raised by tempering from 8·8 to 8·9, and it descends in annealing to 8·7.

Structure of Tin altered by Cold.—At the Exeter meeting of the British Association, M. Fritsche (through Mr. Roberts), communicated a paper on the change which block tin undergoes when exposed to intense cold. M. Fritsche found that the intense cold of St. Petersburg, during the winter of 1867, caused solid blocks of tin to crumble and fall into pieces. That the change was due to intense cold was proved by submitting blocks of tin to a temperature of 40°C., when the same structure was induced.

The Utilisation of Waste Gases from Blast Furnaces.—The blast furnace proprietors who have adopted one or other of the different methods employed for bringing down the gases report satisfactorily of the result. This, with regard to one plant of furnaces, is seen in the circumstance that between 250 tons and 300 tons of fresh drawn slack, heretofore required in raising the steam for their blowing engines and for heating the blast, is now being offered for sale. The concern is that of the Parkfield Iron Company at Wolverhampton.

Quantity of Copper produced in the Year 1866 *over the Whole World.*—The *Chemical News*, quoting from a recent paper by M. Petitgand, states that the quantity of this metal raised on the entire globe in the year alluded to —the latest period that statistical records of this kind have been reliably brought together—amounts to 93,415 tons, which is nearly double the quantity raised in 1846. From the statements made by this author, there appears to be an increasing tendency to a lower cost price of this metal. Large and valuable deposits of excellent copper ore known to exist, especially in Polynesia, are as yet untouched.

MICROSCOPY.

Microscopical Memoirs of the Quarter.—The following valuable contributions to different departments of microscopical science have been published during July, August, and September in the pages of the *Monthly Microscopical Journal*:—

On the Rectal Papillæ of the Fly. By B. T. Lowne, M.R.C.S.—On the Diatom Prism, and the True Form of Diatom Markings. By the Rev. J. B. Reade, M.A., F.R.S., President of the Royal Microscopical

Society.—Observations on the Recent Investigations into the Supposed Cholera Fungus. By the Rev. M. J. Berkeley, M.A., F.L.S. On the Correlation of Microscopic Physiology and Microscopic Physics. By John Browning, F.R.A.S.—Notes on Hydatina Senta. By C. T. Hudson, LL.D.—Some Remarks on the Structure of Diatoms and Podura Scales. By F. H. Wenham.—Structure of the Adult Human Vitreous Humour. By David Smith, M.D., M.R.C.S. On the Use of the Chloride of Gold in Microscopy. By Thomas Dwight, Jun., M.D. —On a Simple Form of Micro-Spectroscope. By John Browning, F.R.A.S. On the Structure and Affinities of some Exogenous Stems from the Coal-measures. By Professor Williamson.—On the Battledore Scales of Butterflies. By John Watson, Esq.—Postscript to Rev. J. B. Reade's Paper on his Prism Structure of the Podura Scale.—On Methods of Microscopical Research. By Herr Stricker.—On the Construction of Object-Glasses for the Microscope. By F. H. Wenham.—Jottings from the Note Book of a Student of Heterogeny. By Metcalfe Johnson, M.R.C.S.—Supposed Mammalian Tooth. By T. P. Barkas, F.G.S.—On Holtenia, a Genus of Vitreous Sponges. By Wyville Thomson, LL.D., F.R.S.—Micro-Spectroscopy, Results of Spectrum Analysis. By Jabez Hogg, F.L.S.—Floscularia Coronetta, a New Species, with Observations on some Points in the Economy of the Genus. By Charles Cubitt, Assoc. Inst. C.E., &c.—On the Detection by the Microscope of Red and White Corpuscles in Blood-stains. By Joseph G. Richardson, M.D.—Observations on Mucor Mucedo. By R. L. Maddox, M.D.—On the Staining of Microscopical Preparations. By Dr. W. R. M'Nab.—Some further Remarks on an Illumination for Verifying the Structure of Diatoms and other Minute Objects. (Almost all these papers are illustrated. Vide *Monthly Microscopical Journal.*)

PHOTOGRAPHY.

Owing to the pressure on our space, occasioned by the great length of some of our original articles and of the table of contents and index to the volume, the photographic summary is unavoidably "crushed out" of this number.

PHYSICS.

The Spectroscopic Examination of Small Stars.—In the *Comptes-Rendus* of July 19, a letter is published from Padre Secchi, in which he states that he has succeeded in studying the spectra of stars which are only of the 8th and 9th magnitude. The light emitted by such stars being very feeble, it is gratifying to learn that observation has proved that, among the spectral lines, those of carbon occur, and that the spectra, as seen, appear to prove a common origin for these small stars which are, comparatively, situated near to each other.—*Chemical News.*

The improved Tuning-fork.—Mr. H. Jones has patented a new form of tuning-fork, of which the following account is given in the specification. The inventor uses a sheath or case, into which he fits a tuning-fork so that the forked ends remain free to vibrate therein, and in such ends openings can be made in the above-named case or sheath, a striker being fitted therein, usually radiated with three, four, or more radii, so that two remain within, and one, two, or more, protrude beyond the case or sheath, which striker, upon being pressed by the thumb or finger, presses the end of the tuning-fork, which, when suddenly relieved, emits the musical sound.

The Spectrum of the Aurora Borealis.—According to the researches of Herr J. A. Angstrom, the light exhibited by the aurora is almost always monochromatic, and shows a single bright line to the left of well-known lines of the calcium group.

How to determine Phosphorescence experimentally.—An instrument has recently been devised by M. Laborde, and has been named the phosphoroscope. It is thus described in *Les Mondes*: It is based upon the same principle as that of M. Becquerel; its essential parts are a Ruhmkorff induction apparatus, the spark of which throws light on the phosphorescent object, and of a sliding frame, one of the ends of which hides the object during the brief moment it is illuminated by the electric spark. This sliding frame is 40 centimètres in length by 10 centimètres in breadth; it is fixed at its centre on an axis, which may be made to move rapidly by means of a pedal. The arrangement of this apparatus is such as to render it serviceable for studying the phosphorescence excited by a blow, as well as by friction. The phenomena of phosphorescence of substances which, like nitrate of uranium, is only of very short duration, can be observed by means of this instrument equally well as the long-continued and strong phosphorescence induced by friction in pieces of porcelain or glass.

Does Sunlight extinguish a Fire?—Mr. Tomlinson thinks he has decided this question, and in a paper read in the Chemical Section of the British Association he expresses the results at which he has arrived. Experiments on the subject are not easily made, in consequence of the many disturbing causes; but from some experiments found in an old volume of the *Annals of Philosophy*, made upon coloured tapers, the conclusion arrived at was that the solar rays, in proportion to their intensity, have the power of retarding to a considerable extent the process of combustion, but this conclusion is open to objection. From a series of experiments upon candles of different sizes and weights, in dark chambers and day and sunlight, Mr. Tomlinson found that the increase of temperature led to increased consumption of material, and *vice versâ*, and the whole result may be stated, that in any case the difference is so small that it may be referred to accidental circumstances, such as temperature and material—the final conclusion being that the direct light of the sun, or the diffused light of day, has no action on the rate of burning, or in retarding the combustion of an ordinary candle.

Condensing Magnetism.—Although this expression is open to objection it explains what is meant by the phenomenon. In a paper lately presented to the French Academy by M. Jamin, this physicist showed that magnetic power may, like electricity, be accumulated. Having, for some special

purposes, had a large horse-shoe magnet made, consisting of ten laminæ of perfectly homogeneous steel, each weighing ten kilogrammes, he suspended it to a hook attached to a strong beam, and, having wound copper wire around each of the legs, which were turned downwards, he put the latter into communication with a battery of fifty of Bunsen's elements, by which means the horse-shoe might be magnetised either positively or negatively, at pleasure. The variations were indicated by a small horizontal needle, situated in the plane of the poles. There was, further, a series of iron plates, which could be separately applied to each of the laminæ. Before attaching any of the latter, the electric current was driven through the apparatus for a few minutes, and then interrupted, whereby the magnet acquired its first degree of saturation, marked by a certain deviation of the needle. One of the iron plates (usually called "contacts") was then put on, and it supported a weight of 140 kilogrammes. A second trial was now made; and the current having passed through again for a few seconds, it was found that the horse-shoe would support 300 kilogrammes, instead of 140. The number of contacts being now increased to five, which together, in the natural state, supported 120 kilogrammes, it was found, after the passage of the current, that they could support the enormous weight of 680 kilogrammes, which they did for the space of a full week. No sooner, however, were the contacts taken off than the horse-shoe returned to its usual permanent strength of 140 kilogrammes. This tends to show that magnetism may be condensed like electricity for a short period.

A new form of Manometric Barometer.—An appliance has been recently devised by Mr. B. Hunt, which is not startlingly novel. It chiefly consists of a metallic lens formed by two very thin membranes, and having a glass tube connected to any part of its circumference. If this lens be filled with liquid and submitted to an external pressure the liquid which fills the same will be forced into the glass tube to a distance which will be longer in proportion as the internal diameter of the glass tube is smaller than the volume of the lens. The latter is enclosed in a case connected by means of a pipe with the pressure to be indicated. If the pressure to which the lens is submitted externally does not deflect the membranes beyond the limits of their elasticity, as soon as the pressure ceases they will return to their original position, and the liquid will re-enter the lens.

Magnetic Variation on the Shores of Lake Superior.—The *Scientific American*, quoting one of the local papers, makes the following statement, which deserves attention and demands confirmation: The magnetic compass, on the north shore of Lake Superior and particularly in surveying around Duluth, is a very zig-zag kind of guide. The assistant surveyor in charge of the transit on the Town Site Survey recently experienced some of its wildest eccentricities of variation. In running and cutting out a transit line between sections on the mountain side, at a certain spot he noticed in a distance of fifty feet a change from 11 degrees east to 17 degrees east; then in a hundred feet further back to 12 degrees east; while five hundred feet further on from 12 degrees 30 minutes east it whirled around to 30 degrees west (!) and kept at that for three hundred feet, and then got back again to 11 degrees east. The surveyor picked up a piece of rock of the granitic species, which seemed to prevail in the locality, and applied it

near his compass, when the needle followed it around the same as it would a true loadstone.

Lord Caithness's Mariners' Compass.—The compass invented by the Earl of Caithness has the following peculiarities: Instead of the two concentric brass rings having their axles at right angles, known as gimbals, Lord Caithness employs a pendulum and ball, which ball works in a socket in the centre of the bottom of the compass bowl. The compass works, therefore, on one bearing on the ball-and-socket principle, and thus maintains its parallelism with the horizon in the heaviest weather.

Browning's Miniature Spectroscope.—This little instrument, which can easily be carried in the waistcoat pocket, is yet a most perfect piece of apparatus; showing Fraunhofer's lines well, and bringing out the absorption of coloured liquids very distinctly. It contains four prisms and an ingeniously contrived adjustable slit. For medical and general spectroscopy it will be found very valuable.

The Open Polar Basin (?)—This is a subject hardly "physical," and yet it touches very closely a question of astronomical physics. Some very important observations have been recently made upon it by Captain Hamilton, in a paper before the Royal Geographical Society. The author having expressed his belief that Baffin's Bay consists of an agglomeration of floes of ice kept apart by gales and tides, goes on to say that, reasoning from analogy, he infers that the Polar basin, which is of much larger extent than Baffin's Bay, must consist of similar floes always in motion where there is an outlet, and therefore he doubts the practicability of spring sledge-travelling from Spitzbergen towards the Pole, and advocates the Smith Sound route for sledge operations; he also believes the best prospect of a ship making progress is by keeping close to the weather shore. No arctic voyager takes the pack if he can avoid it. His observations lead him to the conclusion—1. That there is no practical proof of a warm under-current into the Polar basin, or ameliorated climate caused by its rising to the surface. 2. That the migration of birds is no proof of it. 3. The season at which the open seas of Penny and Morton were seen only show that local causes produce an earlier disruption of the ice there than elsewhere. 4. That the drifts of the Advance, Fox, and Resolute were quite unconnected with any movements of the ice in the Polar basin, and were owing entirely to local causes.

Dr. Miller's Thermometer for Deep-sea Soundings.—Several experiments having convinced Dr. Miller that the ordinary deep-sea thermometer gave too high results, owing to the effect of pressure on the bulb, he was led to devise an instrument to be used in Dr. Carpenter's expedition (the one now, we suppose, concluded), which would give accurate results. The expedient adopted for protecting the thermometers from the effects of pressure consisted simply in enclosing the bulb of a Six's thermometer in a second or outer glass tube, which was fused upon the stem of the instrument. This outer tube was nearly filled with alcohol, leaving a little space to allow of variation in bulk due to expansion. The spirit was heated to displace part of the air by means of its vapour, and the outer tube and its contents were sealed hermetically. In this way, variations in external pressure are prevented from affecting the bulb of the thermometer within, whilst changes of temperature in the surrounding medium are speedily transmitted through

the thin stratum of interposed alcohol. The thermometer is protected from external injury by enclosing it in a suitably constructed copper case, open at top and bottom, for the free passage of the water. In order to test the efficacy of this plan, the instruments to be tried were enclosed in a strong wrought-iron cylinder filled with water, and submitted to hydraulic pressure which could be raised gradually till it reached three tons upon the square inch, and the amount of pressure could be read as the experiment proceeded upon a gauge attached to the apparatus. Some preliminary trials made showed that the press would work satisfactorily, and that the form of thermometer proposed would answer the purpose. These preliminary trials showed that, even in the thermometers with protected bulbs, a forward movement of the index of from 0·5° to 1° Fah. occurred during each experiment. This, however, Dr. Miller believed was caused, not by any compression of the bulb, but by a real rise of temperature, due to the heat developed by the compression of the water in the cavity of the press. This surmise was shown to be correct by some additional experiments made to determine the point.—Vide *Proceedings of the Royal Society*, June.

Physics at the British Association.—Among the many papers read at the Exeter meeting, the following are of interest: *A Self-recording Hygrometer.*—Mr. Vivian described this. At a former meeting he exhibited a self-registering instrument on the cumulative principle of recording mean values of the differences between wet and dry bulb thermometers, and a self-registering maximum and minimum hygrometer. He now produced an improved form, with a series of curves showing the comparative results of Leslie's hygrometer, his maximum and minimum differential, his mean self-registering, which he now offered as the standard. He gave the uses to which it might be put. He had used it in recording the aggregate differences of solar heat of the sun and shade, the duration of rain, and the amount of nocturnal radiations, and many other similar purposes. He now proposed to apply it to recording the actual mean temperature, which would be an important feature, if it could be worked out, and he believed it could, and also to the anemometer.——*A New Anemometer.*—A rough model of an instrument of this kind was exhibited by Mr. C. J. Woodward.——*A Self-recording Aneroid Barometer.*—This instrument, which is manufactured by the Stereoscopic Company, consists of a handsome combination of eight day clock and aneroid. The clock works a revolving cylinder on which a pencil carried from the aneroid by weight and pully records the daily pressure of the air.——*Rock-salt Prisms.*—Mr. Charles Brooke gave an account of his rock-salt prisms. He said that, in his attempts to grind and polish rock-salt prisms in planes not parallel to the lines of cleavage of the crystal, he found that the partly-ground prisms usually cracked and broke at the thinnest end. He and Mr. Browning, the optician, consequently tried the plan of slowly heating the rock-salt buried in sand in a tin vessel, and then permitted the whole to cool very slowly. After this annealing had been performed, it was possible to grind the rock-salt into good prisms.

Mr. Browning's cheap Aneroid.—Mr. Browning has brought out an aneroid barometer of so convenient a size, so accurate in registration, and so cheap, that we cannot help calling the attention of our readers to it. We have had the instrument under observation for a long while, and can speak from experience of its merits.

ZOOLOGY AND COMPARATIVE ANATOMY.

The visual powers of the Eye of Crustacea.—M. Bert, whose curious researches on animal engraftation we described some time since in these pages, has been making some experiments on the effects of light on the eyes of crustacea, and which were communicated to the French Academy of Sciences by M. Milne Edwards. M. Bert has found that the obscure radiations produce no effect on the eyes of these animals. The colour which has the greatest effect is that of the yellow part of the spectrum.—*Comptes-Rendus*, Aug. 2.

A new Acaleph, Callinema ornata, has been discovered on the American coast by Professor A. E. Verrill. It is a very large and fine new jelly-fish, rivalling in size even the common red one, *Cyanea arctica*, which it slightly resembles, and for which it might be mistaken at a distance. It is, however, more yellow in colour, the large complicated ovaries hanging down below the disc being light orange, and the long frilled mouth appendages bright lemon-yellow. The tentacles are about eighty in number, arranged in a nearly continuous circle, and may extend fifteen or twenty feet in large specimens. They are also very remarkable in being flat and broad, with one edge double and divided into crenulated scallops, which are margined with white, producing a very beautiful appearance. The whole body and tentacles give a white phosphorescent light. The largest specimen was eighteen inches in diameter. It is remarkable that so conspicuous an animal has so long escaped observation. It belongs to a family previously unknown on the coast, and forms the type of a new genus.—Vide *American Journal of Science*, July.

Berardius Arnuxii.—A notice of this Ziphid whale was read before the Phil. Society of Canterbury, New Zealand, at a late meeting. The notice was by Dr. Haast the eminent geologist.

The Practical Zoology of the Oyster.—M. Coste, member of the Institute, Inspector-General of Fisheries, has been charged by the Minister of Agriculture and Commerce with an enquiry into the causes of the late mortality in the oyster beds, and the means of preventing a recurrence of the calamity. The great heats have been fatal to the fish in all the beds of the south-west coast of France and in the Channel.

Recent Researches on the Calopteryginæ.—At the meeting of the Royal Academy of Belgium, on June 5, M. de Selys-Longchamps made a communication on the Calopteryginæ. In his first synopsis he described no less than 100 species of these. In a supplement published in 1856 he made known 118 more; and in the present paper he adds thirty-two more new species.

Deep-sea Dredging in 2,435 fathoms.—At the meeting of the British Association the Rev. A. Merle Norman read a letter from Professor Wyville Thomson describing some of the results of the recent dredgings of the Porcupine. Professor Thomson had recently dredged in the Bay of Biscay to the depth of 2,800 fathoms, and the letter gave an interesting account of the casting of the dredge at such a depth. About 1½ cwt. to 2 cwt. of ooze was the general result of a cast of the dredge, and the thermometric instru-

ments employed showed the temperature to be about 36·4 and life was distributed over the whole area which had been examined. The specimens were of a dwarfed character, owing, probably, to the low temperature.

Is Lepyrus binotatus a British species?—A gentleman who recently found this species—Mr. F. A. Black—and who communicated with *Land and Water* on the subject, has elicited the following reply from J. Keast Lord: "*Lepyrus binotatus* was once recorded by Stephens as being British, but that was many years ago. Then it was altogether blotted out of the list of British insects, and appears to have been entirely unknown until this year, when I am informed of another specimen having been taken besides the one above noted.

Anatomy and Distribution of the Balænopteræ.—On this subject a memoir was laid before the Belgian Academy recently, by M. Van Beneden. The author concluded his paper which was of great length by stating that there are four *Balænoptera* in the North Atlantic, two of large size and two small, and that these differ not only in external form, but by certain peculiarities of skeleton, as may be seen in the different specimens now in the European museums. These species are: (1.) *Balænoptera rostrata.* This animal reaches a length of from 25 to 30 feet; its pectoral fin is white in the middle. There are 48 vertebræ and 11 ribs, and the sternum has the form of a Roman cross. The museums in which there is a skeleton of this species are the following: Paris, Brussels, Gand, Christiania, Bremen, Halle, Greifswald, and the College of Surgeons, London. The author does not believe that fusion, even when nearly complete, of the second and third cervical has any zoological value whatever. It is a purely individual character. He does not share the opinion of those who think that this union is one of the characters which serve to distinguish *Balænoptera* from *Physalus.* The axis is soldered to the eighth cervical in several skeletons of *B. rostrata,* in a skeleton of *B. Swinhoei,* and in one of *B. bonærensis*; in the latter the fourth cervical is further soldered to the third. (2.) *B. borealis.* This animal is from 30 to 35 feet long; its pectoral fin is all black. The vertebræ are 56 in number, the ribs are 14, and the sternum has the form of a disc. Its skeleton is in the museums of Brussels, Leyden, Bergen, and Berlin. (3.) *B. musculus.* This animal is from 70 to 80 feet long, sometimes even more than this; its pectoral fins are black. It has 62 vertebræ, 15 ribs, and the sternum has the form of a *trèfle.* It is the commonest of the species. Its remains are to be found in Paris, Lyons, Boulogne, Saint-Brienc, Perpignan, Brussels, Antwerp, Louvain, London, Cambridge, Edinburgh, Alexandra Park, Isle of Wight, Christiania, Bergen, Greifswald. (4.) *Balænoptera Sibbaldii.* This animal is from 70 to 80 feet long. Pectoral fins are black. It has 63 or 64 vertebræ and 15 or 16 ribs. Its sternum is very feebly developed. There is a head at Copenhagen, and "remains" at the British Museum, at Hull, and at Edinburgh. Of these four species the one most often met is *B. musculus.* After it comes *B. rostrata.* The *B. borealis* and *B. Sibbaldii* are much more rare.

Chair of Zoology in the University of Dublin.—The Board of Trinity College have elected a Professor of Zoology in the room of Dr. Wright, recently appointed Professor of Botany. There were three candidates, and the board elected Mr. Alexander Macalister to the office.

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